SURGERY AUGUST 1961
Gynecology & Obstetrics VOLUME 113
NUMBER 2

CHANGES IN THE HEPATIC BLOOD VESSELS IN CIRRHOSIS OF THE LIVER

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THE WORK reported herein is a comparative study of the blood vessels in the normal and cirrhotic livers in which volumetric changes in the hepatic blood vessels—hepatic arteries and portal and hepatic veins—have been measured. For a long time it has been known that the hepatic vasculature becomes altered in cirrhosis of the liver. A number of investigators have reported on some of this abnormal vascular morphology. The notable recent study by Madden showed that a marked reduction in the hepatic venous system was evident in cirrhosis, especially when ascites was present. Madden's studies were done by injecting the three systems with different colored latex materials, after which a visual judgment was made of the vascular variations from the normal pattern which seemed to pertain in the cirrhotic liver. In our study we have quantitated these changes and report our method and results herein.

METHOD AND MATERIALS

The hepatic artery, portal vein, and attached vena cava of human livers, taken at autopsy, were cannulated and perfused with saline to remove blood clots. The liver was then weighed. The hepatic artery was next injected with a 12.5 per cent solution of vinyl plastic in acetone and the liver weighed again. The same procedure was repeated after injection of the portal and hepatic veins with the same material. A different color was used in the medium for each system; namely, red for the hepatic artery, yellow for the portal vein, and blue for the hepatic vein. The solution used was capable of reaching into vessels of about 100 microns in diameter. The termination of each injection was the point at which no further solution could be manually forced into a given vascular compartment. After injection, the liver was digested in concentrated hydrochloric acid and the cast allowed to dry. The large vena cava was then removed and weighed, and its calculated wet weight at the time of injection was subtracted from the wet weight of the hepatic veins. This step was necessary since injection via the vena cava was the practical method of filling the hepatic venous system. Since the weights of plastic material in each vascular compartment were known, a quantitative com-

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Aided by a grant from the U. S. Public Health Service.

TABLE I.—VOLUME OF VASCULAR COMPARTMENTS OF NORMAL AND CIRRHOTIC LIVERS

Liver, grams	*Total vascular bed, grams*	*Hepatic artery, grams*	*Portal vein, grams*	*Hepatic vein, grams*	*Inflow tract, grams*	*Outflow tract, grams*
			NORMAL LIVERS			
2199	240	16	106	118	122	118
1594	162	12	69	81	81	81
1803	148	10	70	68	80	68
1988	192	9	90	93	99	93
2727	284	13	147	124	160	124
1632	212	14	98	100	112	100
1772	252	12	116	124	128	124
1645	214	16	96	102	112	102
Average:						
1920	213	13	99	101	112	101
			CIRRHOTIC LIVERS WITH ASCITES			
1469	75	9	54	12	63	12
2251	152	19	75	58	94	58
1061	113	12	62	39	74	39
2395	205	13	107	85	120	85
2035	185	13	101	71	114	71
1556	129	13	66	50	79	50
1734	100	16	48	36	64	36
1281	140	21	82	37	103	37
Average:						
1723	137	15	74	49	89	49

parison could then be made between the weight, and indirectly the volume, of each vascular compartment in normal and abnormal livers. Also, comparisons between the vascular compartments and the weights of normal and abnormal livers could be made. In these volumetric and weight studies the function of flow, of course, is not considered.

Eight normal livers and 8 livers from patients with advanced cirrhosis, portal hypertension, and ascites were successfully prepared for study. The diagnoses were confirmed by clinical data and histologic studies as well.

RESULTS

When a corrosion cast of a normal liver in which the blood vessels have been injected by different colored opaque media is inspected, the vascular pattern is uniform and always reproducible in approximately an identical manner. Such a corrosion cast of a normal liver is shown in Figure 1a. One can see the intimate relation of the portal veins, yellow, and the hepatic artery, red. The blue vessels are the hepatic veins. The overall picture is the same in all normal livers. A regular relationship between the portal and hepatic venous systems resembling an interdigitation is noteworthy in the normal liver. The corrosion cast of a cirrhotic liver is shown in Figure 1b, and at once it is apparent that gross distortion of topography and loss of vascular substance has taken place. The intimate relationship of the vascular components to each other is disrupted, and there is a marked, visible decrease in hepatic venous outflow tract.

We were unable to identify any shunts between the different vascular compartments in the normal or the cirrhotic livers by our injection techniques. The following data offer a more accurate estimation of vascular compartment volumetric changes in the abnormal liver than the eye can judge.

In Table I the weights of livers and vascular compartments are given for the 16 specimens studied. These weights can be interpreted to represent volumes of the vascular systems for our purposes. Several gross observations can be made. In the first place, the cirrhotic liver weighs approximately 10 per cent less than the normal liver—an average of 197 grams. But of more significance is the marked decrease in the total vasculature of the cirrhotic liver. The vascular volume in the normal livers averaged 213

grams as compared with an average of 137 grams in the cirrhotic livers (Table I, Fig. 2). The total vascular bed reduction in the cirrhotic liver is then in the neighborhood of 36 per cent. This decrease of 36 per cent in the vasculature as compared to only 10 per cent in the total liver weight suggests that vascular loss is relatively greater than parenchymal loss in cirrhosis.

This total loss of 36 per cent in the hepatic vasculature in cirrhosis must be kept in mind as a frame of reference when the reader begins to study the separate components of the hepatic vasculature in health and disease.

HEPATIC ARTERY

The hepatic artery volume increases from 13 grams in the normal liver to 15 grams in the cirrhotic liver (Table I, Fig. 2). This system is the only one that shows an actual increase in cirrhosis, but the increase is only 15 per cent. Yet when this small increase is projected against the total vascular loss in cirrhosis, it can be seen that the relative increase in the size of the hepatic artery is an impressive 83 per cent because in the normal liver the artery is only 6 per cent of the total vasculature, whereas in the cirrhotic it is 11 per cent (Fig. 3). This increase is borne out on visual inspection of the corrosion casts (Fig. 1a and b).

PORTAL VENOUS SYSTEM

In Table I and in Figure 2 it can be seen that the volume of the portal venous system is decreased in cirrhosis. The average portal venous volume in the normal liver is 99 grams as contrasted with 74 grams in the cirrhotic liver, a loss of 25 per cent in cirrhosis. Yet the portal venous system appears to have increased in corrosion casts of the cirrhotic liver (Fig. 1b). This visual impression is erroneous, however, and is the result of the fact that the portal venous system represents 56 per cent of the total vasculature in cirrhosis, while in the normal liver it represents only 46 per cent (Fig. 3). Its apparent increase of 22 per cent in cirrhosis is

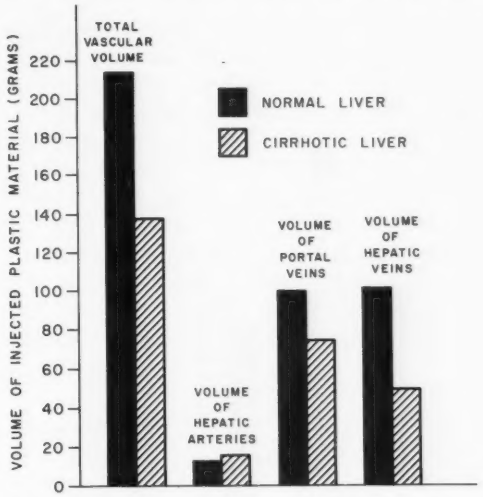

FIG. 2. Comparative changes in the vascular volumes of the normal and cirrhotic liver.

therefore relative and related to the marked reduction in the total vascular volume of the cirrhotic liver.

HEPATIC VENOUS SYSTEM

The most significant change in the hepatic vasculature in cirrhosis is encountered in examination of the hepatic veins. Here visual impressions coincide with the actual and relative loss in the hepatic veins. Thus, while the hepatic venous system's volume is 101 grams in the normal liver, it is only 49 grams in the cirrhotic (Table I, Fig. 2), an actual loss of 51 per cent. The relative change in the hepatic veins parallels the actual loss since the hepatic venous system represents 47 per cent of the total vascular bed in the normal liver but only 36 per cent in the cirrhotic liver—a relative decrease of 23 per cent (Fig. 3).

INFLOW-OUTFLOW TRACTS

In the normal liver the volumes of the inflow tract, hepatic artery plus portal vein, and the outflow tract, hepatic veins, are approximately the same (Table I). In the cirrhotic specimens there is a marked difference between these two vascular compo-

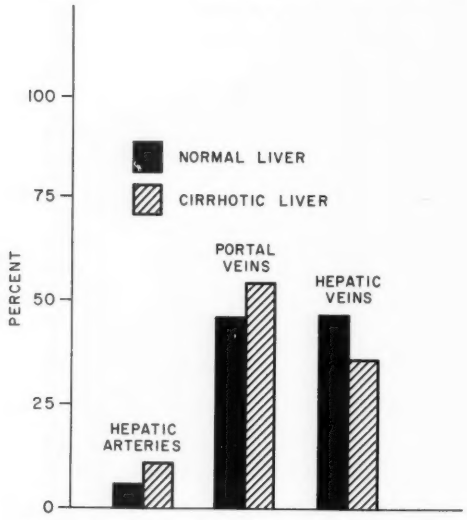

FIG. 3. Percentage of total vascular bed represented by each component in normal and cirrhotic livers.

nents because the hepatic venous system is so reduced. Thus the inflow tract volume in the normal liver is 112 grams and the outflow tract 101 grams, while these figures for the cirrhotic liver are 89 grams for the inflow tract and 49 grams for the outflow tract.

It should also be noted that the inflow tract volume in the normal liver is 112 grams, while the inflow tract volume in the cirrhotic liver is only 89 grams—a loss of 21 per cent (Table I). Corrosion casts (Fig. 1a and b) do not permit this observation because one's visual data are only comparative in the specimens; that is to say, the greater prominence of both the portal vein and hepatic artery vessels in the cirrhotic liver is a function of the marked reduction of the hepatic venous system.

Finally, the great disparity between the volumes of the inflow tract, an average of 89 grams, and the outflow tract, an average of 49 grams, in the cirrhotic liver is most important in demonstrating the importance of outflow block in cirrhosis of the liver. Thus, while the inflow tract and outflow tract are approximately equal in the normal liver, in the cirrhotic liver the outflow tract is but 55 per cent of the inflow tract (Table I).

DISCUSSION

The observation of a decrease in the volume in the hepatic venous outflow tract in cirrhosis is not new. Kretz in 1905 recorded these changes in corrosion casts of cirrhotic livers, and this observation was confirmed by McIndoe in 1928, Popper and associates in 1952, Mann and coworkers in 1953, and Madden and associates in 1954, all using one form or another of corrosion cast techniques. However, before Madden's work, most investigators, although recording the changes in the hepatic venous bed, did not recognize their importance and tended to emphasize the changes seen in the other hepatic vascular elements. Investigators who used perfusion techniques, Herrick, McIndoe, and Dock, also became preoccupied with changes in the portal vein or hepatic artery or the pressure relationships between them, to the exclusion of exploring the significance of possible changes in the outflow tract.

Madden was the first to emphasize the great importance of a reduced hepatic venous bed in cases of ascites. Our work corroborates his finding in this regard. However, we do not agree with his statement that the portal venous bed is increased in ascites. Instead, we believe that there is an actual reduction in the portal venous system in cirrhosis with ascites. The portal venous system seems larger because of the relatively greater loss in total hepatic vasculature. The vascular compartment volumes in the normal and the cirrhotic liver have been quantitated in the present study, and thus a more definitive estimation of vascular changes in disease has been permitted than visual observations allow.

Finally, we would like to add that the recorded changes in cirrhosis with ascites fit in well with current concepts of the parenchymal changes seen in cirrhosis. As the disease progresses, there is replacement of liver parenchyma by fibrous tissue in some areas and distortion of architecture in others by regenerating nodules. The thin-walled, unprotected, low pressure hepatic veins are

easily destroyed and distorted by the disease process and hence show the greatest change. The higher pressure portal vein protected by the stroma of the portal triad is subject to the same ravages but is more resistant and consequently exhibits less change.

The magnitude of the marked reduction in the hepatic venous outflow tract in advanced cirrhosis is of the order of 50 per cent. This finding is a consistent one when persistent ascites has been present. It is therefore rational to provide hepatic decompression via the portal vein by side-to-side portacaval shunt in patients who have cirrhosis of the liver with ascites (8). By supplying an auxiliary outlet for the congested liver, the side-to-side shunt in effect makes up for the reduction in the volume of normal venous outflow.

SUMMARY AND CONCLUSIONS

1. By corrosion cast technique volumetric changes in the hepatic vasculature of 8 normal and 8 cirrhotic livers with ascites were recorded.

2. The normal liver presents a uniform, intricate, and reproducible vascular pattern, while the cirrhotic liver with ascites exhibits a marked distortion and disruption of all components of the hepatic vasculature.

3. There is a significant decrease in the total hepatic vasculature in liver cirrhosis with ascites, which is due primarily to a marked decrease in the hepatic venous outflow tract.

4. In this study the hepatic venous system was reduced by 51 per cent on the average in livers taken from patients with advanced cirrhosis and ascites.

5. The decrease in the hepatic venous outflow tract with secondary hepatic congestion is the probable cause of the complication of ascites which often accompanies cirrhosis of the liver with portal hypertension.

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PHYSIOLOGIC CHANGES ACCOMPANYING PROFOUND HYPOTHERMIA

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PROFOUND HYPOTHERMIA, used in conjunction with cardiopulmonary bypass, is being employed with increasing frequency during those cardiac operations which necessitate a prolonged perfusion period or total circulatory arrest. There has been much discussion as to the optimal rate of cooling. Sealy and his associates (10, 11), for example, have advocated relatively slow temperature reduction during a period of partial bypass while Bjork and Drew and his associates (5, 6) have induced hypothermia rapidly. Regardless of the rate at which cooling is accomplished it has been generally agreed that a reduced arterial flow is permissible at lower temperatures, and this principle has been observed in both clinical practice and the majority of experimental studies of the combined techniques. Thus little information is available concerning the physiologic consequences of profound hypothermia per se when perfusion rate is maintained constant. Pierce and associates studied organ blood flows indirectly at a low flow rate during hypothermia and Lopez-Belio and associates determined total peripheral resistance, with particular reference to blood viscosity, at various perfusion rates and temperatures.

In the present study total systemic vascular resistance and the blood flows in several peripheral vascular beds were measured in dogs at temperatures between 35 and 10 degrees C. while flow was maintained at a constant high rate.

METHODS

A single rotor occlusive pump and a rotating disc oxygenator were employed in the extracorporeal circuit. A Brown-Harrison heat exchanger was placed in the arterial return line to permit regulation of temperature. The perfusion rate—systemic flow—was measured by a recording rotameter in the arterial line distal to the heat exchanger. The rotameter was calibrated for each of the temperature ranges employed. Arterial and central venous pressures were measured with Statham pressure transducers attached to catheters in the aorta and inferior vena cava. The pressures were recorded, along with the amplified signal from the rotameters, on a multichannel oscillograph. The temperatures of the animals were recorded from a thermistor probe in the esophagus at the level of the aortic arch.

Healthy, fasting mongrel dogs weighing 14 to 21 kilograms were anesthetized with intravenous administration of 30 milligrams of thiopental per kilogram. A cuffed endotracheal tube was inserted and positive pressure respiration was maintained by a piston-type respirator supplying room air. The right pleural cavity was entered through the fourth intercostal space, and a second incision through the tenth intercostal space was made to provide access to the abdominal organs. Drainage catheters were placed in both atria to decompress the heart during bypass. After the animals had been heparinized by 3 milligrams per kilogram of body weight the venae cavae and femoral artery were cannulated and total cardiopulmonary bypass was instituted. In every experiment perfusion flow was maintained constant throughout at a rate of 80 to 95 cubic centimeters per kilogram per minute. The arterial pump was totally occlusive and

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alterations in the speed of the pump were seldom necessary to maintain a constant flow, even at low temperatures. Total systemic venous return was also measured in a number of the experiments to provide an additional record of total flow. In no experiment did systemic flow decrease more than 8 per cent with cooling.

When femoral arterial blood flow was measured, the artery was cannulated proximally and distally, and the blood was diverted through a recording rotameter. Common carotid and hepatic arterial blood flows were measured similarly. Splanchnic blood flow—total portal venous return—was measured by timed collections after a large catheter had been inserted into the portal vein and the vein ligated at the liver. Renal blood flow was measured similarly by drainage of an isolated vena caval segment at the level of insertion of the renal veins.

Measurements were made, after institution of total bypass, during a 10 minute control period at an esophageal temperature of 35 degrees C. The temperature of the heat exchanger was then reduced to 1 degree C., and the temperature of the animals was lowered to 10 degrees C. over a 15 to 20 minute period. Central aortic pressure—the index of systemic vascular resistance—and organ blood flows were measured at each 5 degree C. temperature decrement. The animals were maintained at 10 degrees C. for 10 minutes and then rewarmed by the introduction of water at 40 degrees C. into the heat exchanger. The rewarming periods averaged 20 to 25 minutes. When the esophageal temperature had been restored to 35 degrees C. pressures and blood flows were again measured during a second 10 minute control period.

RESULTS

Total peripheral vascular resistance. Observations of mean aortic and central venous pressures were made in 29 animals. No significant alteration in central venous pressure was noted with temperature change. At a constant arterial flow, as employed in these

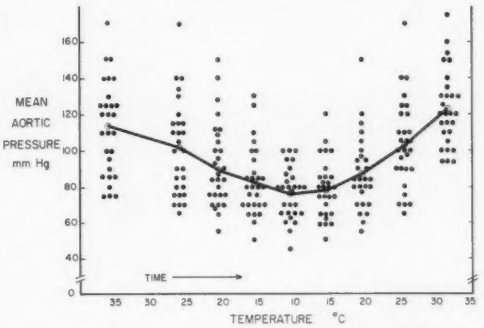

FIG. 1. Mean central aortic pressures determined in 29 dogs during extracorporeal circulation at various temperatures. The average values are connected by the solid line.

studies, total systemic vascular resistance is a function of mean arterial pressure less mean venous pressure. Since the latter parameter remained constant, vascular resistance was directly reflected by the mean aortic pressure. The average mean aortic pressure at 35 degrees C. was 113 millimeters of mercury; in every animal it fell progressively with cooling and at 10 degrees C. the average mean aortic pressure was 76 millimeters of mercury (Fig. 1). Rewarming resulted in a rise of the aortic pressure toward the control level, and when the temperature had returned to 35 degrees C. the average value was 123 millimeters of mercury. The total vascular resistance at 10 degrees C. was thus an average of 30 per cent lower than during the initial control period at 35 degrees C.

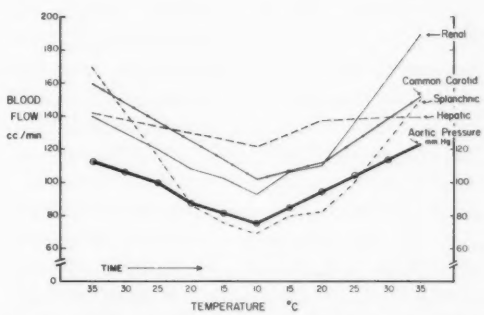

FIG. 2. Carotid, hepatic, splanchnic, and renal blood flows and mean aortic pressure during extracorporeal circulation at various temperatures.

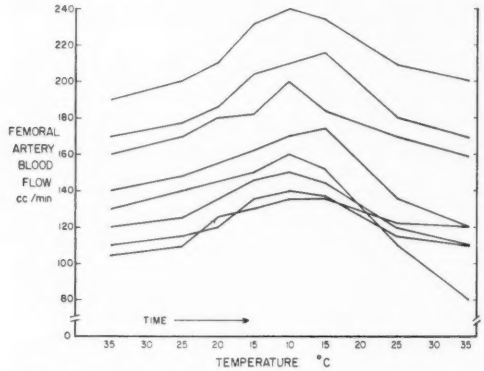

FIG. 3. Femoral blood flow during extracorporeal circulation at various temperatures. Each curve represents observations in an individual animal. The flow values are not corrected for total body weight.

Carotid arterial flow. Carotid arterial blood flow was measured in 6 animals and fell progressively as temperature was reduced. At 10 degrees C. flow was an average of 29 per cent lower than at 35 degrees C. During rewarming carotid flow returned to the initial control level (Fig. 2).

Hepatic arterial flow. Hepatic artery flow was determined in 5 animals and the values at various temperatures are also plotted in Figure 2. The change in flow was much less than in the other vascular beds and the average flow at 10 degrees C. was only 15 per cent lower than control levels.

Splanchnic portal venous flow. Measurements of venous return from the portal vein were made in 6 dogs and flow fell strikingly in all of them as the temperature was reduced. Maximum reduction was noted at 10 degrees C. where flow was 60 per cent less than control levels. During both cooling and rewarming the rate of change in portal flow was maximal between 35 and 25 degrees C. (Fig. 2).

Renal venous flow. Renal venous return was also measured in 6 animals. Again a rapid and progressive fall in flow was observed as the temperature was reduced (Fig. 2), and at 10 degrees C. the average flow was 34 per cent less than the initial control level. With rewarming it was noted that the rate of change in flow was more rapid than during cooling and when the temperature had been returned to 35 degrees C., flow was an average of 40 per cent higher than during the initial control period (Fig. 2). The periods of observation were not prolonged in order to observe the ultimate changes in this parameter.

Femoral arterial flow. Observations of femoral artery flow were made in 8 dogs. In contrast to the results outlined in the foregoing a consistent increase in flow was noted with the induction of hypothermia. Between 35 and 25 degrees C. the flow changed only slowly, with either cooling or rewarming, but rapidly between 25 and 10 degrees. At this lowest temperature, the average flow was 25 per cent higher than during the control periods. The individual measurements in the 8 animals are plotted in Figure 3, and a segment of the continuous records of femoral artery flow and aortic pressure made in 1 of them is reproduced in Figure 4.

COMMENT

As noted previously, the study described was designed to permit an assessment of the effects of hypothermia, independent of perfusion rate, upon total and regional resistance and flow. An average decrease in central aortic pressure of 30 per cent was noted to occur with cooling to 10 degrees C. In similar experiments reported by Kahler and associates a reduction in pressure of 28 per cent was found to accompany hypothermia at 15 to 25 degrees C. In the composite graph shown in Figure 2 it is apparent that blood flow through the kidney, head, and splanchnic bed fell in direct proportion to the decrease in systemic arterial pressure. Since the venous pressure distal to the first two beds was measured and found to be unchanged, it may also be concluded that the resistance to flow in the kidney and head did not alter significantly. Since the portal venous pressure was always maintained at a low level, it would seem that similar considerations would apply in the splanchnic bed as well. Little change in hepatic artery flow

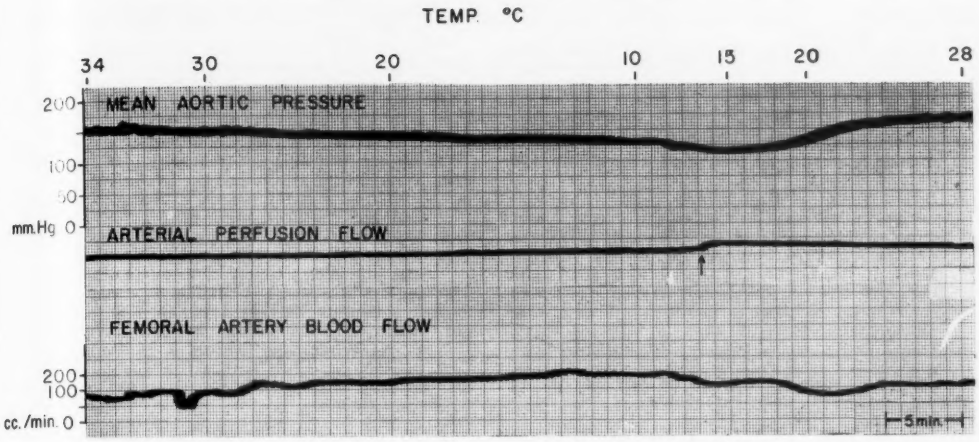

FIG. 4. Portions of the records of mean aortic pressure, systemic—perfusion—flow, and femoral artery flow obtained in a typical experiment. As the temperature is decreased there is a decline in aortic pressure and a rise in femoral artery flow. Both values return to near control levels with rewarming. The sharp deflection in the perfusion flow record, arrow, is an artifact.

was noted. However, previous studies by Dow and associates have shown that striking alterations in portal venous pressure may occur in dogs during cardiopulmonary bypass, and the portal pressure, in these experiments, was not measured when hepatic artery flow was determined. Accordingly, no conclusions as to changes in the resistance across the liver can be drawn from these data.

In contrast to the other vascular beds studied, flow in the femoral artery, considered to be representative of flow to other skeletal muscle masses, was found to increase with hypothermia. The venous pressure distal to this vascular bed—femoral venous and vena caval pressure—did not change and it is clear that resistance to flow in the limb decreased significantly with cooling and increased during the rewarming period (Fig. 4). A similar reduction in resistance with hypothermia has been shown by Berne and by Bernhard and associates to occur in the coronary vascular bed. These and the present data thus seem to indicate that the observed reduction in total systemic vascular resistance probably occurs primarily because of reduction in resistance to flow through muscle masses, both skeletal and myocardial. No conclusion can be drawn from these experiments concerning the mechanism by which the increase in extremity blood flow is effected. It could result, of course, from a change in arteriolar tone, mediated either locally or centrally, or by the opening of direct arteriovenous communications known to exist in the limb.

SUMMARY

Total systemic vascular resistance and carotid, hepatic, splanchnic, renal, and femoral blood flows were measured in dogs at temperatures of 35 to 10 degrees C. during total cardiopulmonary bypass at a constant high rate of perfusion. Total vascular resistance at 10 degrees C., as reflected by mean central aortic pressure, was 30 per cent lower than control levels. Flow in the head, splanchnic bed, and kidney decreased in proportion to the change in pressure but femoral artery flow increased as the temperature was reduced. The studies indicate that the reduction in total systemic vascular resistance observed with profound hypothermia results primarily from a decrease in resistance to flow through muscle masses.

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AN EXPERIMENTAL STUDY OF THE INFLUENCE OF IMPLANTED POLYURETHANE SPONGES UPON SUBSEQUENT BONE FORMATION

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IN THE CONTINUING SEARCH for an ideal bone graft material a great many substances have been employed. Bone in one form or another—fresh autogenous, homogenous, deproteinized bone, decalcified bone—and bone substitutes, certain plastics, and plaster of paris, have been more or less widely employed. Fresh autogenous bone is accepted as the best available grafting material. All other substances used incorporate in one way or another certain undesirable reactions which apparently retard new bone formation.

The ideal material is one which will: (1) serve as a structural framework upon which bone can form, (2) obstruct or inhibit the formation of less desirable tissue, and (3) exert an inducing action to facilitate or accelerate bone formation. While fresh autogenous bone more nearly fulfills these criteria than any other material, the desirability of having available a synthetic bone substitute which would perform equally well is obvious.

Our studies (2) on polyurethane sponges of varying pore sizes implanted subcutaneously into rats indicated that the size of the pores had a striking effect upon the type and the rate of subsequent connective tissue formation within the sponges. Sponges with small pores were filled rapidly by practically avascular collagenous tissue; those with large pores were filled more slowly by mature areolar tissue. Mesenchymal tissue filled all of the sponges, but the rate of formation and the type and degree of differentiation was influenced by the spatial arrangement of the structure within which these changes took place.

It was logical to extend these observations to bone not only because of the rapid fibroplasia which took place within the sponges when implanted subcutaneously, but because the structure of the open pore polyurethane sponge is strikingly similar to cancellous bone. This fact suggested that it might at least serve as an excellent structure to support bone formation.

MATERIALS AND METHODS

The characteristics of polyurethane polymer sponge have been described previously. These sponges are flexible, yet sufficiently rigid to maintain their contour when placed within tissues. The pore size can be varied and the variations standardized; the pores may be either open or closed. Sponges of 6 different pore sizes have been used in previous studies and arbitrarily designated as Nos. 1 through 6. In this study, open pore sponges of size No. 1, with 90 pores per linear inch, and of size No. 5, with 15 pores per linear inch, were used.

Immature mongrel dogs approximately 12 weeks old were quartered in separate cages and maintained on standard dog chow. Using intravenous sodium pentobarbital anesthesia and observing strict aseptic technique, we exposed the proximal tibial metaphysis by an anteromedial approach.

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This study was supported by Grant A 1073-C4 from the National Institutes of Health.

FIG. 1.

FIG. 2.

FIG. 1. Photomicrograph of control defect at 2 weeks. The defect has been filled by highly cellular and vascular fibroblastic tissue in which numerous small foci of ossification are seen. ×22.

FIG. 2. Photomicrograph of pore size No. 1 sponge at 2 weeks. The sponge is filled by a sparsely cellular, virtually avascular collagenous tissue. There is abundant new bone formation in a highly vascular stroma just outside the sponge but this ceases abruptly where this bone encounters the connective tissue which has formed within the sponge. ×22.

A rectangular window was made in the cortex and the underlying cancellous bone thoroughly curetted creating a defect approximately 3 centimeters in length in the metaphysis. A total of 35 such defects was created in 31 animals.

Cylinders of sponge 3 centimeters in length were trimmed to conform to the contour of the defects so created.

In 14 defects, cylinders of No. 1 sponge were inserted, and, in 15 defects, cylinders of No. 5 sponge were inserted. Six defects were not implanted with sponges and these served as controls.

After implantation, the cortical windows were replaced and the fascia and skin closed in layers.

At intervals during a 16 week period, the tibias were harvested. Longitudinal sections of the proximal tibias, including the area in which the sponges were implanted, were fixed in 10 per cent formalin, decalcified in 5 per cent formic acid, and embedded in paraffin. Microscopic sections were cut at 5 microns and stained with hematoxylin and eosin, Wilder's silver impregnation, and toluidine blue.

RESULTS

Controls. Within 2 weeks, the surgically created cavity was filled by a loose, highly vascular connective tissue in which abundant coarsely woven bone formed. The new bone was located peripherally and sur-

FIG. 3.

FIG. 4.

FIG. 3. Photomicrograph of pore size No. 1 sponge at 10 weeks. The junction between the area occupied by the sponge and adjacent cancellous bone is seen on the right. The tissue filling the sponge is dense collagen, almost devoid of blood vessels. ×22.

FIG. 4. Photomicrograph of the margin of a pore size No. 1 sponge at 10 weeks. Minimal collagenous osteogenesis is seen at the periphery of the sponge. ×38.

rounded a central, vascular, fibroblastic nidus in which small foci of active osteogenesis existed (Fig. 1). At 4 weeks, the cavity had been completely obliterated and the area of the former defect was occupied by new bone, usually more abundant than in adjacent untraumatized areas. After this period there was a gradual remodeling of the new bone and formation of hematopoietic marrow. In 1 animal at 6 weeks a central nidus of dense, avascular, collagenous tissue persisted in which there was no evidence of bone formation.

Pore size No. 1 sponges. Soon after implantation the sponges filled with blood. At 1 week, the sponges were more than half filled by connective tissue and by 2 weeks nearly avascular, fairly loose collagenous tissue completely filled all the interstices (Fig. 2). While abundant new bone surrounded the sponges, none was seen within them. By 4 weeks, the tissue filling the sponges was dense, sparsely cellular, virtually avascular collagen. After this period of time there was little change in the tissue. Formation of bone about these sponges ceased abruptly at the point where the new bone encountered the dense connective tissue (Fig. 3). Occasionally, within this dense collagen, small islands of hematopoietic cells were seen.

After 8 weeks, minimal quantities of metaplastic bone were observed to have formed in the collagen at the periphery of the sponges (Fig. 4), but still no new bone

FIG. 5.

FIG. 6.

FIG. 5. Photomicrograph of pore size No. 5 sponge at 2 weeks. The sponge is filled by a fibrillar, moderately cellular, and sparsely vascular connective tissue. New bone which is seen in the lower half is typical of the florid ossification which occurred about the sponges and stopped where it met the tissue filling the sponges. ×22.

FIG. 6. Photomicrograph of No. 5 pore size sponge at 4 weeks. The tissue within the sponge is seen in the upper half and new bone which formed about the sponges in the lower half. This demonstrates the continuation of collagen fibers which have been incorporated in new bone into the sponge. ×38.

was observed within the substance of the sponges. In 2 specimens, the sponges had become fragmented and scattered trabeculae of the sponge lay in an apparently normal metaphysial bone and hematopoietic marrow. These sponges had been implanted for 12 to 16 weeks. In 1 specimen, in which the sponge apparently maintained its integrity, hematopoietic marrow and cancellous bone were present within the sponge at 8 weeks. These instances were exceptions to the otherwise consistent failure of bone formation within the sponges.

Pore size No. 5 sponges. Evidence of initial hemorrhage and early connective tissue formation in the periphery of the sponges was seen at 1 week. At 2 weeks, the sponges were filled with a moderately cellular, dense fibrous tissue which contained few vessels (Fig. 5). There was abundant new bone formation about the sponges but none within them. Just as in the small pore sponges, bone formation ceased abruptly where it met the tissue in the sponges although collagen fibers of the bone continued into the tissue within the sponges (Fig. 6). Once the sponges were filled, the tissue became more and more dense and less cellular (Fig. 7). This situation obtained in all except 3 specimens throughout the duration of the experiment. In these 3 instances, variable changes were seen. One specimen

in which the overlying cortical window had become displaced was harvested at 4 weeks. A large amount of new bone had formed both within and about the sponges. This process was continuous with new bone formation beneath the periosteum. It seems that the displacement of the cortical window was a factor in this exceptional reaction. The sponge in another specimen harvested at 6 weeks was only partially filled by fibrous tissue, the remainder being occupied by hematopoietic marrow. A third, after 7 weeks, contained a band of new bone which transversed the central portion of the sponge. This new bone was not in contact with any sponge trabeculae and it is believed that the new bone formed in a rent in the sponge.

FIG. 7. Photomicrograph of pore size No. 5 sponge at 13 weeks. The tissue filling the sponge is hyalinized collagen, avascular and virtually acellular, in which no bone has formed. ×22.

DISCUSSION

It was clear that the sponges did not support or promote osteogenesis. On the contrary, the presence of the sponge resulted in inhibition or blocking of bone formation in the area occupied by the sponge. Apparently this inhibition was not the result of any property of the material composing the sponges, but was due to the extremely rapid fibroplasia which occurred within the sponges.

This conclusion is supported by the few instances in which the sponges became fragmented. In these cases, the fragments did not seem to influence subsequent tissue reaction in the area.

As previously indicated (2), we regard the process of connective tissue formation in subcutaneously implanted sponges as one of in situ fibrogenesis developing an avascular connective tissue which cannot be likened to granulation tissue. The tissue which formed in the intraosseous sponges was very like that tissue and, therefore, could hardly be expected to support bone formation. The fact that small quantities of bone formed by a process of metaplasia within the collagen at the periphery of the sponges suggests that this might have extended gradually throughout the substance of the sponges in an almost endlessly prolonged collagenous osteogenesis.

The studies of Bryan and his associates in which cylinders of polyvinyl-formol sponge were placed in cortical defects support this interpretation. It was concluded that the sponge did act as a framework for bone but that it caused a distinct delay in bone formation which prevented healing for as long as 1 year.

While our results were essentially the same as theirs, we cannot agree with the assertion that the sponge in any way acted as a framework for bone formation. Actually, in our experiments, the only possible ways for bone to form within this dense tissue filling the sponges could be either by replacement of the collagen by more cellular and vascular tissue or by a very gradual process of collagenous osteogenesis or metaplasia with-

in the collagen. The sponge would play no part in this process.

Occasional exceptions in which bone formation occurred within the sponges indicated that if the substance of the sponges was disrupted there was no inhibition of bone formation. The presence of small islands of hematopoietic marrow in the collagen within some of the sponges suggested that a gradual replacement of collagen by hematopoietic cells might occur. This seems to have occurred in 2 of the sponges which were used.

SUMMARY

Open pore polyurethane polymer sponges were implanted in the proximal tibial metaphyses of immature mongrel dogs and harvested at various intervals during a 16 week period. With few exceptions, the sponges were filled rapidly by a virtually avascular collagenous tissue which effectively prevented the formation of bone within these sponges.

There were exceptions in which bone formed in the area occupied by the sponges. These exceptions were due either to fragmentation of sponges or to incorporation of hematopoietic cells within the collagen. We believe that the inhibition of bone formation was not due to the composition of the sponges but rather to a very rapid fibroplasia within the sponges and to the paucity of vessels in this new tissue. This may be regarded as negative evidence in support of the theory of induction of bone. Further investigative experiments are contemplated.

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INTESTINAL OBSTRUCTION DUE TO FOOD

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THE COMPLICATIONS commonly seen after partial gastric resection are the dumping syndrome, hypochromic anemia, weight loss, increased sensitivity to alcohol, and an increased susceptibility to tuberculosis. In 1955, I described 7 patients in whom intestinal obstruction developed caused by food after partial gastrectomy for peptic ulcer (18.). I pointed out that gastric resection should be considered an important predisposing cause for such obstruction. In 5 patients the obstruction was due to citrus fruits, whereas in the other 2 cases the nature of the obstructing mass was not determined since the bolus was milked down manually into the cecum without enterotomy being performed.

Prior to 1955 only 6 similar cases of intestinal obstruction had been described. These reports were presented by Seifert, Allen and Smithwick, Baumeister and Darling, Fleming and Ward-McQuaid, Stalker and Gotham, and Elfving and Scheinin. However, since 1955 there has been a sharp increase in the number of cases reported. In most instances, the obstruction was caused by orange piths as reported by Rowling, Ryan, MacPhee, Ward-McQuaid (27), Davies (9), MacCarthy, Corbett, Goodman, Cade and Qvist, Gall, Davies and Lewis (9), and Butler, and by coconuts as reported by Rains and associates, Bowen, and Spurzem and Desser. Figs were the obstructing agent in patients described by Spurzem and Desser and Nagel and Bergera. Brussels sprouts were the obstructing agent in the gastrectomized patients described by Colabawalla.

Farreaching conclusions could of course not be drawn from the few cases that I described in 1955 (18). Since that time, however, my experience with this complication has increased considerably in spite of the warning in a Swedish journal to surgeons cautioning them to prohibit their gastrectomized patients from eating citrus fruits (19). The present study was undertaken to examine these cases more closely in the effort to reach definite conclusions concerning this complication.

CLINICAL OBSERVATIONS

Between the years 1951 and 1960, 26 patients were operated upon for intestinal obstruction caused by food at the two departments of surgery of the Sahlgrenska Sjukhuset (Tables I and II). Two of these patients were operated upon twice for this complaint, Patients 3 and 15 and Patients 25 and 26. All of these 26 patients had previously been subjected to gastric resection. Five of the patients were included in my previous report (18).

The nature of the obstructing agent was definitely determined in 14 of the patients described in Table 1, in whom enterotomy had to be performed to remove an obstruction in the small intestine. In Patient 1 the obstruction was caused by segments of grapefruit, and in the other 13 patients it was caused by undigested particles of orange. In patient 2, the bolus consisted of half an undigested orange.

Table II contains a summary of the 14 patients with intestinal obstruction who did not require enterotomy. In these it was possible at laparotomy to break up the obstruction manually and milk it down into the cecum. The last column in Table II contains the surgeon's opinion as to the nature of the obstructing agents. These opinions were later compared with information volunteered by the patients concerning the food taken before the onset of illness. In all but 1 there was agreement between the opinion of the surgeon and that of the pa-

TABLE I.—FOURTEEN CASES OF INTESTINAL OBSTRUCTION DUE TO CITRUS FRUITS VERIFIED AT SURGERY

No.	*Sex*	*Year of birth*	*Year of resection*	*Type of ulcer*	*Type of operation*	*Type of G.E.*	*Year of intest. obstr.*	*Nature of bolus*
1	M	1901	1951	Gastric	B II	Retrocolic	1952	Pieces of grapefruit
2	M	1895	1937	Duodenal	B II	Retrocolic	1953	Half orange
3	M	1918	1945	Duodenal	B II	Retrocolic	1954	Orange segments
4	M	1895	1948	Duodenal	B II	Antecolic	1954	Orange segments
5	M	1919	1951	Duodenal	B II	Retrocolic	1954	Orange segments
6	M	1897	1934	Gastric (carcinomatous)	B I		1955	Orange segments
7	M	1894	1946	Duodenal	B II	Retrocolic	1955	Orange segments
8	F	1904	1943	Duodenal	B II	Retrocolic	1956	Pieces of orange
9	M	1897	1944	Gastric	B I		1956	Orange segments
10	F	1916	1953	Gastric (carcinomatous)	B II	Retrocolic	1956	Orange segments
11	M	1895	1943	Gastric	B II	Retrocolic	1958	Pieces of orange
12	M	1903	1953	Duodenal	B II	Retrocolic	1958	Pieces of orange
13	M	1920	1955	Duodenal	B II	Antecolic	1960	Orange segments
14	M	1910	1957	Gastric	B II	Retrocolic	1960	40 gm. of orange segments

B I, Billroth I partial gastrectomy.
B II, Billroth II partial gastrectomy.
G.E., Gastroenterostomy.

TABLE II.—FOURTEEN CASES OF INTESTINAL OBSTRUCTION CAUSED BY FOOD AFTER PARTIAL GASTRECTOMY IN WHICH AN ENTEROTOMY WAS NOT PERFORMED

No.	*Sex*	*Year of birth*	*Year of resection*	*Type of ulcer*	*Type of operation*	*Type of G.E.*	*Year of intest. obstr.*	*Supposed nature of bolus*
15	M	1918	1945	Duodenal	B II	Retrocolic	1951	Fruit substance
16	M	1910	1939	Duodenal	B II	Retrocolic	1954	Several orange segments
17	M	1904	1947	Duodenal	B II	Retrocolic	1955	Orange segments
18	M	1898	1951	Duodenal	B II	Retrocolic	1955	Pieces of orange
19	M	1901	1946	Duodenal	B II	Retrocolic	1956	Orange segments
20	M	1903	1952	Gastric	B II	Retrocolic	1956	Orange segments
21	M	1920	1954	Duodenal	B II	Retrocolic	1956	Several orange segments
22	M	1909	1947	Duodenal	B II	Retrocolic	1957	Orange segments
23	M	1920	1951	Duodenal	B II	Retrocolic	1958	Pieces of orange
24	F	1910	1957	Sarcoidosis	B II	Antecolic	1959	Orange segments
25	F	1913	1953	Duodenal	B II	Retrocolic	1959	Orange segments
26	F	1913	1953	Duodenal	B II	Retrocolic	1959	Orange segments
27	M	1921	1939	Duodenal	B II	Retrocolic	1960	Orange segments
28	M	1915	1950	Duodenal	B II	Retrocolic	1960	Dried apple

tient. In Patient 15 no information was obtained on the type of food taken before the onset of obstructive symptoms. In 12 patients the obstruction was believed to have been caused by segments of oranges while in Patient 28 the obstructing agent was dried apples. Only 4 of the 26 patients operated upon for intestinal obstruction were women.

Gastric resection had been performed for duodenal ulcer in 18 of the patients, for gastric ulcer in 5, for carcinomatous gastric ulcer in 2, and for sarcoidosis of the stomach in 1. The most common type of operation was the Billroth II—Polya—partial gastrectomy. Billroth I partial gastrectomy was performed on only 2 patients. Among the patients in whom Billroth II partial gastrectomy had been employed, an antecolic type of anastomosis was used in 3, and a retrocolic anastomosis in the remainder.

The longest period of time intervening between the resection and the intestinal obstruction was 21 years which occurred twice, in Patients 6 and 27, and the shortest interval was 9 months, in Patient 1. The average interval between resection and obstruction was 8.3 years.

All operations except one were uneventful. In Patients 25 and 26 an abscess developed in the abdominal cavity after the obstruction had been relieved by manual manipulation of the bolus and the patient

had to be reoperated upon. The postoperative course was at first uneventful but 6 days later the patient died suddenly of pulmonary edema. Autopsy showed no evidence of peritonitis.

In addition to these 26 patients, 4 others with partial gastrectomy were suspected of having intestinal obstruction caused by citrus fruits. In all 4 cases, the patients reported that they had eaten oranges before being seized with intermittent symptoms of nausea, vomiting, and colicky abdominal pain. One recovered after vomiting orange remnants. In the other 3 patients, roentgenologic examination of the abdomen indicated intestinal obstruction but 2 of them were relieved of complaints after the barium meal which subsequently disclosed nothing abnormal in the intestines. The last patient recovered after a conglomeration of orange remnants had been defecated.

DISCUSSION

During a 10 year period, 28 operations were performed in a single hospital clinic for intestinal obstruction due to food. Twenty-six of these were caused by citrus fruits. All of the 26 patients had previously undergone partial gastric resection. The most common type of partial gastrectomy was the Billroth II—Polya—with a retrocolic gastrojejunostomy. This method is the technique most often used at the Sahlgrenska Sjukhuset in the treatment of peptic ulcer. Perhaps for this reason the series included only 1 case of Billroth I partial gastrectomy and 2 cases of Billroth II partial gastrectomy with antecolic gastrojejunostomy.

A patient with intestinal obstruction due to food after a Billroth I partial gastric resection was described by Gall. At operation Gall found a sausage shaped food bolus which was milked down into the cecum. The patient had eaten an orange just prior to the onset of symptoms and Gall was of the opinion that the bolus could well have been orange pith. It is quite possible that more cases of intestinal obstruction following Billroth I gastric resections have been reported, but unfortunately the data are so scanty in many of the reports that it is difficult to determine the type of operation originally performed. However, most of the earlier reports of intestinal obstruction due to food after partial gastrectomy have involved a Billroth II operation. It therefore seems to be of little consequence whether the patient has had a gastroduodenostomy or an antecolic or retrocolic gastrojejunostomy. The risk of intestinal obstruction is apparently due to the absence of a normally functioning pylorus.

During the past 20 years gastrojejunostomy alone has rarely been performed for peptic ulcer at the Sahlgrenska Sjukhuset. There is no record of intestinal obstruction in any of these patients. However, Delrio, Paz, and Carpanelli and Davies and Lewis (8) have reported an intestinal obstruction due to citrus fruits in patients who had previously had only a gastrojejunostomy. Thus, the essential factor determining the occurrence of intestinal obstruction seems to be absence of normal pyloric function rather than degree of gastric resection.

Intestinal obstruction caused by food, especially fruit, may of course occur in patients who have not had a gastric operation. This is most uncommon in Sweden. A detailed survey of the available literature up to 1950 was made by Ward-McQuaid, who described 178 cases of intestinal obstruction due to food (26). Oranges were responsible for the obstruction in 16 of these patients. At the Sahlgrenska Sjukhuset, intestinal obstruction due to citrus fruits has occurred only in patients with previous gastric operations.

Thorough mastication of the food is probably very important for patients with previous gastroenterostomy. The digestive secretions apparently have only a slight effect on orange pith, especially in patients with the diminished gastric secretion that follows gastrectomy, since in several of these patients with intestinal obstruction it was possible to remove from the obstructed intestine orange segments that were almost

entirely undigested. It has been pointed out by other investigators that artificial teeth are a frequent feature in these cases, but in my experience, this has not been a prerequisite for the occurrence of intestinal obstruction due to food.

The conventional operations for peptic ulcer, namely, Billroth I and II partial gastrectomy, vagotomy with gastrojejunostomy, vagotomy with antrum resection, or pyloroplasty, all lead to the loss of normal pyloric function. At the Sahlgrenska Sjukhuset between 400 and 500 operations for peptic ulcer are performed annually and the number of these operations, both in this hospital and elsewhere, seems to be increasing every year. It is therefore probable that the number of cases of intestinal obstruction due to food will also increase. This type of intestinal obstruction is an entirely unnecessary complication and can be easily avoided. All patients who have been operated upon for peptic ulcer or who have undergone partial gastrectomy for some other complaint should be instructed to masticate fruit, especially oranges, thoroughly or perhaps better to partake only of orange juice.

SUMMARY

Intestinal obstruction due to phytobezoars is a complication not uncommonly occurring in patients who have previously undergone gastroenterostomy or gastric resection. Diminished gastric secretion, together with loss of normal pyloric function, may be factors which permit the pith of citrus fruits or indigestible cellulose to form obstructing masses in the small intestine. Patients who have previously had partial gastrectomy, gastrojejunostomy, or pyloroplasty should be instructed to masticate fruit thoroughly and avoid swallowing intact fruit segments.

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EFFECT OF PORTACAVAL SHUNTING ON HYPERCHLOREMIC ACIDOSIS IN ANIMALS

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IN 1877, Eck described the production of a fistula between the portal vein and inferior vena cava that subsequently became known as the Eck fistula. It was soon found, however, that this fistula was not compatible with normal life. It has now been definitely established that ammonia may accumulate in the blood stream after a portacaval shunt, but this material is probably only one of a group of toxic substances derived from the digestion of protein in the intestinal tract.

In 1957, McDermott reported ammonia intoxication in a patient with an ileal bladder who had hepatitis and an infection caused by urea-splitting organisms, and in 1958 Silberman recorded a similar case in which the condition developed in a cirrhotic patient subjected to ureterosigmoidostomy.

When a 0.9 per cent solution of sodium chloride is injected at a constant rate into the portal circulation of the rat, as Bollman has indicated, it produces a reduction in urinary volume during the first 24 hours with an increased concentration of urine and a decreased excretion of chloride. A similar response is not obtained when the injection is made into the systemic venous circulation or when other cations are used in place of sodium. This response apparently is only temporary, being replaced later by an increased output of urine and chloride. Nevertheless, because of this finding, it appeared to us that the liver, when exposed to the portal circulation containing the products absorbed after diversion of urine to the colon, in some way might alter the state of hyperchloremic acidosis. Elucidation of this problem was the reason that the present investigation was undertaken.

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Abridgment of thesis submitted by Dr. Hayward to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Surgery.

METHODS

To substantiate the validity of the aforementioned statements concerning the intravenous administration of sodium chloride, the experiment was repeated on 4 rats. Suprapubic cystostomy was performed on all animals to allow collection of urine, and fine polyvinyl tubing was inserted into the inferior vena cava of the first 2 rats and the portal vein of the other 2 rats. A 0.9 per cent solution of sodium chloride then was injected at a constant rate of 20 milliliters per 24 hours, and a record was made of the urinary volume and excretion of chloride. After confirmation of the previous observation of reduced urinary volume and chloride excretion with the administration of saline into the portal vein, it was decided to shunt the portal vein of dogs into the inferior vena cava by 4 separate surgical procedures and at 4 different points along the course of the former, either before or after the experimental production of hyperchloremic acidosis.

The normal anatomy of the intestinal venous circulation and portal vein was determined in 2 dogs by injecting a mixture of barium and gelatin into the venous vascular bed of the entire intestine; this solution contained 10 milliliters of water, 20 grams of gelatin, and 40 grams of barium sulfate,

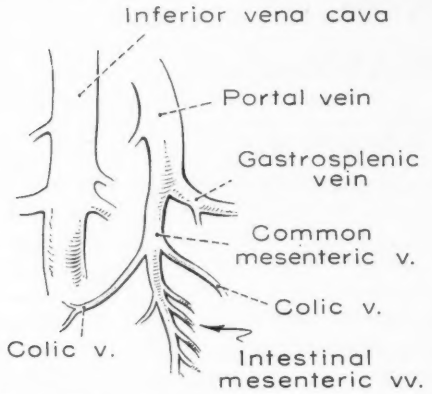

FIG. 1. Diagrammatic representation of tributaries of portal vein.

plus methylene blue or some other suitable coloring agent. When this material had hardened, it was possible to demonstrate the venous pattern of the intestine by roentgenography and, also, to dissect and trace the individual vessels. The main intestinal mesenteric vein, which drains the small intestine from the jejunum to the cecum, usually is joined by 2 veins from the colon. One of the latter branches drains the region of the appendix and upper part of the colon and anastomoses with branches of the main intestinal mesenteric vein, whereas the other runs parallel to the colon and receives multiple branches along its course. The somewhat larger vein formed by the junction of all these veins is the common mesenteric vein, which, after a course of 0.5 to 1.5 centimeters, receives the gastrosplenic and gastroduodenal veins and, thereafter, becomes the portal vein (Fig. 1).

Urinary diversion. Except when otherwise stated, urine was diverted by anastomosis of the bladder to the cecal region of the colon, the fecal stream being diverted by ileosigmoidostomy. This procedure was employed because it almost invariably produces hyperchloremic acidosis as previously reported (2), and the object of the study was to determine the effect of a portal shunt on such acidosis.

Portal shunts. The portal vein and inferior vena cava were exposed through a right thoracicoabdominal incision in the twelfth intercostal space and were dissected free from the surrounding tissues. The aorta was isolated just above the renal arteries with a strand of heavy linen thread; it was occluded only during anastomosis of the portal vein. The 4 different shunts employed are called type I, II, III, or IV for convenience.

Type I.—This shunt, involving transposition of the portal vein and inferior vena cava (Fig. 2a), was performed on 6 dogs as a primary procedure and was followed later by diversion of urine to the upper part of the colon. In 1 dog, the portacaval transposition was performed after the urinary diversion and during a state of hyperchloremic acidosis.

Type II.—This shunt involved end-to-side anastomosis of the common mesenteric vein to the inferior vena cava (Fig. 2b). The operation was carried out as a primary procedure in 9 dogs and was followed later by diversion of urine to the upper part of the colon in 7 of these animals; in the 2 remaining dogs in this group, the venous shunt was followed by anastomosis of the trigone of the bladder to the rectum. In a group of 3 dogs, urinary diversion preceded the establishment of such a shunt. In creating the anastomosis, a semilunar piece of vena cava usually was excised in order to provide a wide opening; in 1 instance, however, only a longitudinal slit was made in the vein.

Type III.—This shunt involved anastomosis of the main intestinal mesenteric vein to the inferior vena cava (Fig. 2c). In this instance, the blood containing the reabsorbed urinary products was not diverted from the hepatic circulation. The procedure was performed on 5 dogs prior to urinary diversion and on 2 dogs after urinary diversion. On 2 occasions, only a longitudinal opening was made in the inferior vena cava, without excision of a semilunar portion of the vein wall.

Type IV.—In this procedure, the colic veins were ligated and divided near their point of entry into the common mesenteric

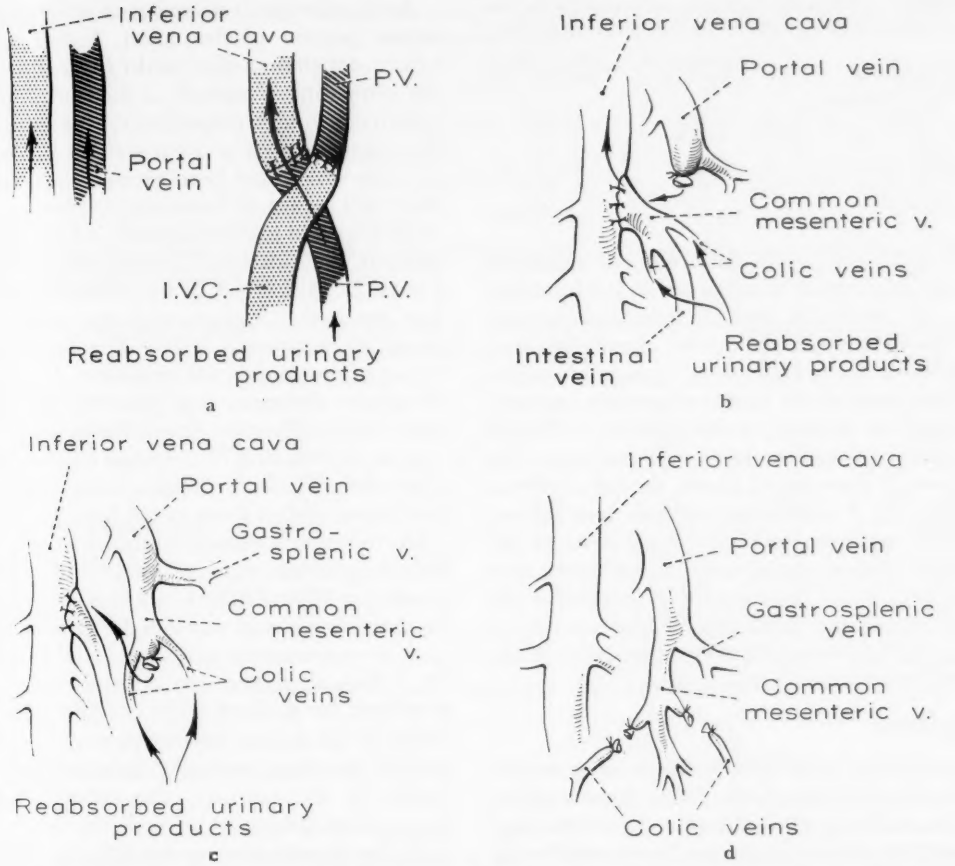

FIG. 2. Diagrammatic representation of the 4 types of shunts. a, Type I—portacaval transposition. b, Type II—common mesenteric vein shunt. c, Type III—anastomosis of main intestinal mesenteric vein to inferior vena cava. d, Type IV—ligation of colic veins.

vein (Fig. 2d). This was done in 3 dogs after urinary diversion, but it is difficult to conceive what hemodynamic changes might follow this operation. The colonic venous blood could be redirected through other venous channels back into the portal circulation or through direct anastomoses to the inferior vena cava. Probably both courses were followed.

Other studies. All animals in these 4 groups were studied by repeated recording of body weight, blood *p*H, plasma carbon dioxide-combining power, and serum chloride; in several instances, blood ammonia was determined by the method of Seligson and Hirahara. The other laboratory techniques have been detailed elsewhere (2). The objectives were to ascertain: (1) whether a preceding venous shunt would alter the severity of the expected hyperchloremic acidosis of the urinary diversion; (2) whether a venous shunt would change an already established state of hyperchloremic acidosis; and (3) the effect, if any, of the combined surgical procedures on the health of the animals.

Four of the dogs were given oxytetracycline (terramycin) orally, in a dose of 0.5 to

TABLE I.—URINARY VOLUME AND CHLORIDE EXCRETION IN RATS DURING INFUSION OF SALINE

Site of infusion	*Urinary vol. per 24 hrs., ml.*	*Chloride excretion per 24 hrs., mEq.*
Inferior vena cava		
Rat 1	38.8	5.7
Rat 2	45.0	5.7
Portal vein		
Rat 3	25.4	4.1
Rat 4	25.6	2.6

1 gram per day in an attempt to minimize the production of ammonia in the intestine.

In the dog, a variable number of anastomoses between the portal circulation and inferior vena cava occur normally; therefore, some of the absorbed urinary products could be shunted in this fashion to the systemic venous circulation. To minimize this normal shunting of blood, the inferior vena cava in 4 additional animals was ligated with tape just below the renal veins at the time of diversion of urine to the upper part of the colon. These dogs were studied in the usual fashion to determine the severity of hyperchloremic acidosis and the effect of the operation upon survival time.

RESULTS

Effects of saline infusion into portal or systemic venous circulation of rat. Table I summarizes the variations of chloride excretion and urinary volume in the rat in response to the intravenous infusion of a 0.9 per cent solution of sodium chloride. When the injection was made into the portal vein rather than the inferior vena cava, the urine was concentrated and small in volume and contained decreased quantities of chloride.

Effect of diverting portal blood with reabsorbed urinary products into systemic venous circulation. Type I shunt.—All 6 dogs which had preliminary portacaval transposition maintained good health and a normal acid-base balance, although the serum chloride was slightly increased in 3 instances to 114.4, 114.4, and 114.8 milliequivalents per liter, respectively. The blood ammonia was measured in 1 dog and was within the normal range. One of these 6 animals died later, before the second operation.

After subsequent diversion of urine to the upper portion of the colon, 1 dog died before detailed studies could be made. Of the remaining 4 animals, 2 died in a toxic state 6 and 7 days, respectively, after urinary diversion; the first of these animals was one of those which had been given a daily oral dose of 1 gram of terramycin. Neither of these dogs had hyperchloremia. The other 2 animals, dogs 78 and 77, were observed for 15 and 22 days, respectively (Table II). The first received 0.5 gram and the second 1 gram of terramycin daily. The usual increase of serum chloride seen after this type of urinary diversion was observed in both dogs, but the characteristic acidosis failed to appear; in fact, dog 77 even had alkalosis on 1 occasion. The latter animal remained in a toxic state and at times could barely stand, while the value for blood ammonia increased from the previously normal level of 173 micrograms per 100 milliliters to 735 micrograms on the day the dog was killed. Administration of terramycin was discontinued in dog 78, 7 days after diversion of urine, and the dog lived for another 8 days. The mode of death in this animal was not observed; however, as the shunt was found to be somewhat narrowed at necropsy, the reduction of blood flow through the anastomosis may have been sufficient to modify the toxic manifestations.

Two days after portacaval transposition was performed on the dog already in a state of hyperchloremic acidosis as a result of previous urinary diversion, the animal appeared to be in a toxic state; by the third morning, it was unconscious and was breathing deeply, the forelegs being extended in a state of tetanic spasm. The value for serum chloride had decreased from 121.6 milliequivalents per liter to the almost normal level of 111.4 milliequivalents and alkalosis had replaced the previous acidosis, with an increase in the carbon dioxide-combining power from 15.83 millimols per liter to 30.6, and an increase in blood *p*H from 7.139 to 7.290.

Necropsy did not reveal an explanation

TABLE II.—CHANGES IN BLOOD AFTER DIVERSION OF URINE TO UPPER COLON IN 2 DOGS WITH PORTACAVAL TRANSPOSITION

*Constituent**	*Dog No.*	*Control period†*	*Days after urinary diversion* 3	7	8	9	11	15	17	22
	77	114.4			119.6	122.3			116.3	119.7
Serum chloride	78	114.4	114.3	122.8	122.0		119.5	118.3		
	77	24.26				23.31			27.53	26.17
Plasma CO_2—combining power	78	28.07		21.37	22.92		23.14	24.61		
	77	7.292				7.300			7.410	7.352
Blood *p*H	78	7.340		7.273	7.306		7.320	7.311		

*Normal values: serum chloride, 110 milliequivalents per liter, range 107.1–113.6; plasma CO_2-combining power, 25.47 millimols/liter, range 23.55–27.67; blood *p*H, 7.314, range 7.235–7.385.
†After portacaval transposition but before urinary diversion.

TABLE III.—CHANGES IN BLOOD AFTER DIVERSION OF URINE TO UPPER COLON IN 4 DOGS WITH COMMON MESENTERIC-VEIN SHUNT

*Constituent**	*Dog No.*	*Control period†*	*Days after urinary diversion* 3	4	6	7	8	11	12	16	20	10 weeks
	85	111.5			116.1	124.8		115.1				
Serum chloride	86	113.5			112.8			121.4				124.1
	87	110.6			116.6		117.0		121.4	120.2	110.4	
	91	115.3	114.6	121.7		129.5						
	85	29.46				25.19		28.89				
Plasma CO_2—combining power	86	26.88						20.61				16.32
	87	27.95									24.25	
	91	25.18										
	85	7.336				7.296		7.388				
Blood *p*H	86	7.331						7.244				7.134
	87	7.349									7.267	
Blood ammonia	85	207.0			575.0		396.0					

*Normal value for ammonia=171 micrograms per 100 milliliters, range 166–177. See Table II for other normals.
†After common mesenteric-vein shunt but before urinary diversion.

for death in any of the animals with a type I shunt.

Type II shunt.—Studies after the preliminary shunt revealed a normal acid-base balance in all 9 dogs, although the values for serum chloride were a little above normal in 3 animals. In the 1 instance in which the blood ammonia was determined, an increase to 256 micrograms was noted. The value decreased to 207 micrograms after 2 days of fasting.

Six of the 7 dogs in which urine subsequently was diverted into the upper part of the colon survived for 2, 3, 5, 7, 11, and 20 days, respectively; the seventh was still alive after 14 months. All dogs observed before death except for this last one were in a toxic state and had difficulty in maintaining their balance. A significant further increase in the blood ammonia in the 1 animal thus studied, dog 85, Table III, was noted, despite the oral administration of 0.5 gram of terramycin per day; although hyperchloremia of the usual severity occurred in this dog, obvious acidosis was not detected. Dogs 87 and 91 both had hyperchloremia. The seventh animal, dog 86, was the exception in that toxic symptoms were not observed, although the usual hyperchloremic acidosis developed; however, in this animal, only a slit was made in the inferior vena cava when the venous shunt was created, and the blood flow through the shunt may have been restricted for this reason. Data in this group are summarized in Table III.

Of the 2 dogs in which urine was diverted subsequently by transplantation of the trigone of the bladder to the rectum, 1 died after 2 days and the other after 7 days. Changes in the value of serum chloride were not observed in the 1 animal thus studied; ammonia concentrations were not determined.

In the 3 dogs which had urinary diversion

before the shunt only moderately severe hyperchloremic acidosis was noted after the urinary diversion. However, they survived for only 1, 4, and 5 days, respectively, after establishment of the venous shunt, dying before blood studies could be carried out. One animal was in a definitely toxic state before death, and the appearance of one of the others suggested terminal tetany.

In no instance did necropsy reveal any explanation for the death of these animals with a type II shunt.

Type III shunt.—Of the 5 dogs in which the shunt was done first, 2 were killed because paraplegia developed after the aorta was clamped and 1 died of evisceration 6 days after urinary diversion. The remaining 2 animals had hyperchloremic acidosis of the usual severity seen with this type of urinary diversion. One of these dogs lived for 13 days and the other for 2 months. At necropsy, the venous anastomosis of the first was thrombosed; apart from this, no significant abnormalities were found in either.

Both of the animals which had urinary diversion before the venous shunt demonstrated hyperchloremic acidosis after diversion of urine to the upper part of the colon. Paraplegia developed in 1 dog after the aorta was clamped when the shunt subsequently was established; therefore, it was destroyed. The other lived for 6 months in a state of hyperchloremic acidosis after recovery from the second operation. Abnormalities were not detected at necropsy.

Type IV shunt.—As noted previously, this procedure was performed on 3 dogs after diversion of urine to the upper portion of the colon. One dog was already in an extremely poor condition, and its health continued to deteriorate after the second operation. In the other 2 animals, the state of hyperchloremic acidosis was not altered by ligation of the colic veins.

Effect of diversion of urine to upper colon with ligation of inferior vena cava. All 4 animals in this group maintained good health and demonstrated hyperchloremic acidosis of the usual severity.

COMMENT

The findings presented make it apparent that the shunting into the canine systemic circulation of blood containing urinary products absorbed from the colon is definitely detrimental to the health of the animal. With either operation alone, namely a venous shunt or urinary diversion, the dog remained in good condition, but a combination of an effective venous shunt with diversion of urine to the upper part of the colon had a fatal outcome. This was also true of 2 dogs with diversion of urine into the rectum, although it was expected that exposing a smaller area of colonic mucosa to urine would minimize absorption of the toxic urinary constituents. Death followed more rapidly when animals were subjected to a portal shunt while in a state of hyperchloremic acidosis than it did when the operations were performed in the reverse order.

That the response of the animal depends upon the adequacy of the shunt and upon the constituents in the shunted blood was demonstrated clearly. Except in 1 instance, the dogs' health deteriorated rapidly after a type I or type II operation, portacaval transposition or common mesenteric vein shunt; however, in this particular animal, blood flow through the anastomosis was undoubtedly minimal owing to the fact that only a longitudinal incision had been made in the inferior vena cava. The type III—diverting only small-intestinal blood—and type IV—ligation of colic veins—shunts were without demonstrable effect on the state of hyperchloremic acidosis or the health of the dogs.

Before death, most animals appeared to be in an extremely toxic state and were ataxic. Four dogs, 3 with a type I shunt and 1 with a type II shunt, were given terramycin orally, but the antibiotic did not appear to be of benefit. The toxic symptoms were definitely intermittent and usually became worse shortly after a meal; 2 dogs had an increased concentration of ammonia in the peripheral blood while receiving terramycin. Several animals were in a state of tetany

at the time of death. These findings suggest that ammonia intoxication contributed to the death of the dogs in this study.

It is noteworthy that acidosis was not observed in dogs with an effective shunt; in fact, slight alkalosis was demonstrated at times, although hyperchloremia often became obvious if the animals survived for a sufficiently long period. It is reasonable to assume that stimulation of the respiratory center by ammonia was responsible for this finding.

Although the administration of terramycin did not prevent ammonia intoxication, it may have helped minimize its severity; however, the failure of antibiotics to save the animals suggests that the greater part of the ammonia absorbed by the colon is derived from the urine and that the administration of antibiotics is of little benefit unless perhaps urea-splitting organisms are active in the intestine. The concentration of ammonia in the peripheral blood was normal in dogs with urinary diversion alone, although Rosenberg has noted increased values in the sigmoid vein and portal blood of such animals; nevertheless, when the liver is bypassed by this blood, dangerous systemic concentrations may result. Thus, it must be emphasized that ureterosigmoidostomy never should be performed in the presence of hepatic disease or after a portacaval shunt.

The 4 animals subjected to ligation of the inferior vena cava maintained excellent health, although hyperchloremic acidosis of the usual severity appeared in each instance. This type of "reversed shunt," therefore, did not impair the health of the dogs in this study and was without effect on the development of hyperchloremic acidosis.

SUMMARY AND CONCLUSIONS

A study was carried out in dogs to determine whether a portal systemic shunt could modify hyperchloremic acidosis which resulted from diversion of urine to the colon.

The effective shunting of portal blood containing urinary constituents absorbed from the colon into the systemic circulation was universally fatal. Ammonia intoxication frequently followed this operative procedure. Hyperchloremia without acidosis developed in some of the animals so treated. The absence of acidosis or the appearance of alkalosis probably was secondary to stimulation of the respiratory center by ammonia.

The administration of antibiotics did not benefit this condition.

This study supports the contention that ureterosigmoidostomy should not be performed in the presence of severe hepatic disease or after a portacaval shunt.

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THE EFFECT OF NITROGEN MUSTARD ON CIRCULATING CANCER CELLS AND PULMONARY METASTASES FROM AN EXPERIMENTAL CECAL CARCINOMA

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MANIPULATION of a tumor occurs frequently during the process of examination for tumor, exploration, and therapeutic procedures. Many early workers in the field of neoplastic diseases suggested that manipulation would enhance the dissemination of the tumor. This question again has been raised with the development of suitable techniques for the identification of cancer cells in the blood. Engell first showed that tumor cells were present in the circulating blood in the presence of resectable tumors, which led to a consideration of methods to control spread of tumor by this means. Cole and associates advocated ligation of the venous trunks leading from the tumor area before manipulation and later suggested that chemotherapeutic agents be used as adjuvants in surgery.

Only animal investigation can furnish within a reasonable time a quantitative evaluation of the importance of manipulation and the value of chemotherapeutic agents. The simulated colon carcinoma in rats reported previously (2), affords an opportunity for such a quantitative evaluation.

The experiments to be reported were designed to determine: (1) the effects of manipulation of the reproducible cecal carcinoma and (2) whether these effects could be altered by the use of nitrogen mustard.

MATERIALS AND METHODS

Female Wistar rats from Charles River farms weighing 180 to 200 grams were used for these experiments. The simulated colon carcinoma were produced by implantation of a gelatin capsule containing Walker 256 carcinosarcoma into the wall of the cecum. Two weeks after the implant of the tumor exploration was carried out and the rats were divided into resectable and unresectable groups. The tumor was considered unresectable if it was over 1.6 centimeters in size or if lymph node, liver, or peritoneal implants were present.

The weight of the tumor at the time of removal, the survival time of the rats in weeks, and the number of local recurrences or metastases were noted and recorded. Autopsy was performed on all animals at the time of death. All surviving animals were sacrificed and autopsies performed at 9 weeks.

Cytologic studies. Blood was drawn from the inferior vena cava and aorta of rats with resectable and unresectable tumors and was prepared by Seal's technique, and quantitative tumor cell counts were made.

At the start of the experiment it was believed that tail vein injection of the nitrogen mustard would be satisfactory. However, we could never be certain that the injection was intravenous. The method described by Grossi and associates of surgical exposure of the femoral vein with direct injection using a 24 gauge needle was more satisfactory.

THE EFFECT OF MANIPULATION

Two hundred and forty rats were used for this experiment. Two weeks after the implantation of the tumor exploration was carried out and the 240 rats were divided into 3 groups as follows: (1) Resectable. In

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This work was supported by grant No. H2867 of the National Institutes of Health, No. C3817 of the National Cancer Institute, and institutional funds.

this group of 101 rats the tumor was gently manipulated for 3 minutes, and then a cecoappendectomy was performed about 1 centimeter distal to the tumor. (2) In this group of 93 rats only the cecoappendectomy was performed, and every effort was made to minimize manipulation of the tumor. (3) Unresectable. This group of 46 rats included those in which the primary tumor was over 1.6 centimeters in size or in which lymph node, liver, or peritoneal metastases were present. For this group surgery was only exploratory.

Group 1. Of the 101 rats in this group in which a resectable tumor was manipulated, liver metastases developed in 29. Five occurred within 1 to 3 weeks, 21 occurred within 4 to 8 weeks, and 3 were found at autopsy at 9 weeks. The average survival time for this group of rats was 4.6 weeks, and the average nodule size was 8 millimeters (Fig. 1). It should also be noted that recurrence at the local site was found in 24 of these animals, or 24 per cent. Lymph node metastases were found in 13 per cent.

Group 2. Of the 93 rats in this group with resectable tumor and no manipulation, liver metastases developed in 13, or 14 per cent. Five occurred in rats that died within 1 to 3 weeks, 5 in rats that died within 4 to 8 weeks, and 3 were found at autopsy at 9 weeks. The average survival time for this group of rats was 6.7 weeks, and the average nodule size was 5 millimeters (Fig. 2). Local recurrence at the site of resection occurred in only 17—18 per cent—of these animals, somewhat fewer than in the manipulated group. Lymph node metastases were also seen in 8—9 per cent—of these animals (Table I). The rate of recurrence in the abdominal wound was similar in the two groups.

Group 3. In the rats with unresectable tumor only exploration was performed, and there was no manipulation of the primary tumor. Of the 46 rats in this group hepatic metastases developed in 8—17 per cent. Four occurred in rats that died in 1 to 3 weeks, and 4 in rats that died in 4 to 8 weeks.

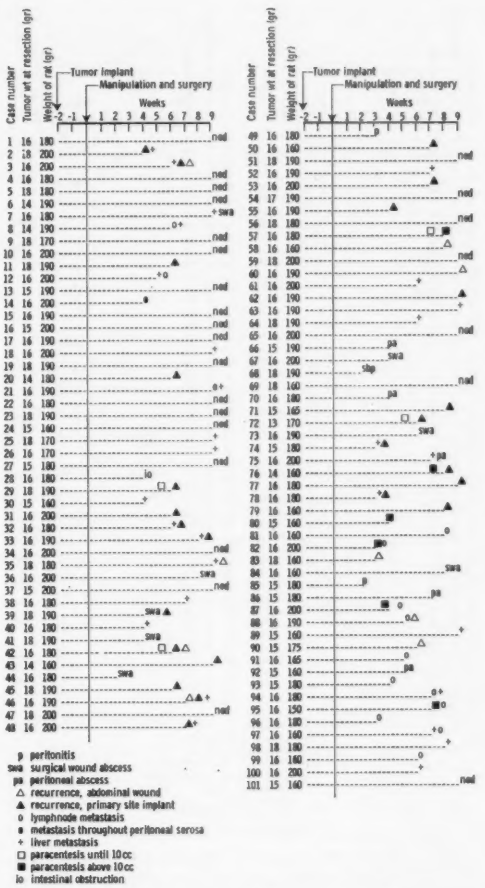


FIG. 1. Rats with manipulation of resectable tumors, group 1. Tumor weight at resection, weight of the rat, survival time of the rat in weeks, and the many peritoneal, wound, and tumor recurrence complications are recorded.

All 46 died of tumor in less than 9 weeks. The average survival time for this group was 3.2 weeks; and the average nodule size was 1.2 centimeters. In this group 50 per cent had lymph node metastases, and of course all had persistent local tumor (Table I).

Cytologic study. Blood from the portal vein, vena cava, and aorta was obtained from 42 resectable and unresectable rats. In the resectable rats, no cancer cells were found at any time before manipulation of the tumor.

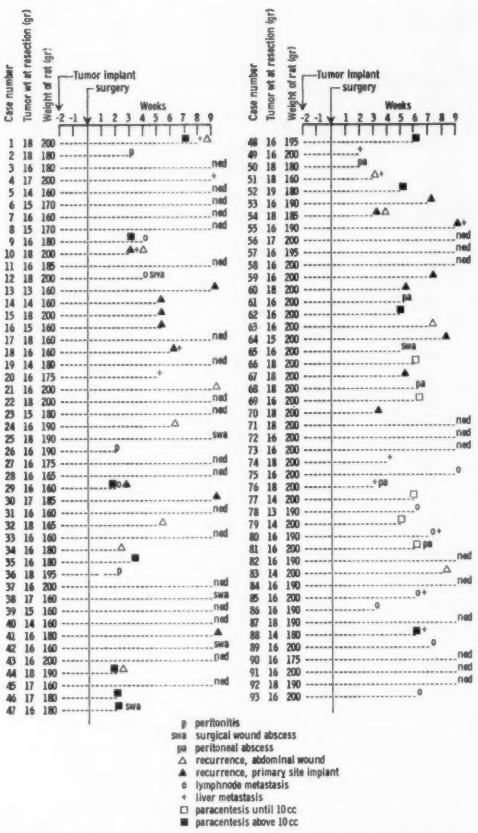


FIG. 2. Rats with resectable tumors, not manipulated, group 2. Tumor weight at resection, weight of the rat, survival time in weeks, and the many peritoneal, wound, and tumor recurrence complications are recorded.

If the tumor was gently massaged a shower of cancer cells occurred which lasted for about 5 minutes (Fig. 3, solid line). These cells disappeared from the circulating blood whether the tumor was clamped and removed or left in place. In the unresectable group cancer cells were seen in all animals prior to manipulation (Fig. 4, solid line). When the tumor was gently massaged the number of cancer cells increased significantly, but after 5 minutes the number of cells counted returned to the original high level. Clumps of the cancer cells were noted at the time of showers in all the resectable and unresectable animals studied.

EFFECT OF NITROGEN MUSTARD

A cecal tumor was formed as before in 200 rats. At 2 weeks, exploration was again performed and the 200 rats were divided into two groups, 158 with resectable tumors and 42 with unresectable tumors. The resectable and unresectable groups were again divided into two groups, in one of which nitrogen mustard was given and the other acted as a control.

The 4 groups were as follows: (1) Unresectable. In this group of 20 rats the tumor was not removed nor was nitrogen mustard administered. (2) Unresectable. In this group of 22 rats the tumor was not removed. Treatment consisted of 0.4 milligram of nitrogen mustard per kilogram. (3) Resectable. The tumor was resected in these 80 animals but no nitrogen mustard was given. (4) Resectable. These 78 rats received 0.4 milligram of nitrogen mustard per kilogram 15 minutes before the primary tumor was resected.

All animals were kept for 9 weeks and then sacrificed. In these and the rats which died before 9 weeks autopsies were performed at the time of death. They were examined for liver and lung metastases. No other type of recurrence was recorded in these series.

Cytologic data. The results in the resectable animals, groups 3 and 4, with and without manipulation were the same as in the previous experiment (Fig. 3). The nitrogen mustard was given after the manipulation, and the cell count fell to 0 in 5 minutes (Fig. 3, broken line) in both groups.

In the unresectable animals treated with nitrogen mustard, group 2, a definite difference was noted (Fig. 4). If nitrogen mustard was injected 15 minutes before manipulation, the increase in cancer cells was markedly diminished as compared with the controls not receiving nitrogen mustard. Forty-eight hours after the administration of nitrogen mustard the number of cells reached their lowest level. There was then a gradual increase in numbers to the prenitrogen mustard levels.

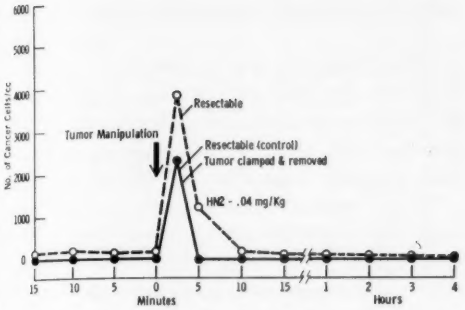


FIG. 3.

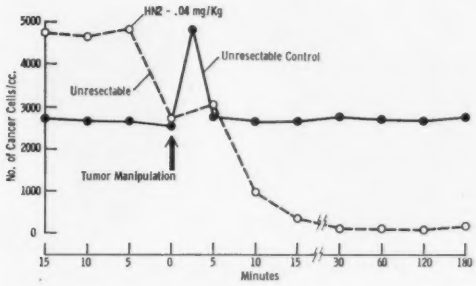


FIG. 4.

FIG 3. Cancer cells in vena caval blood of rat with resectable tumor. Solid line represents the controls; dashed line, nitrogen mustard treated. No tumor cells were found in the resectable animals prior to massage of the tumor. There was a sharp increase in the number of cancer cells with manipulation and then a rapid return, within 5 minutes, to the absence of cells. The same thing occurred in control and nitrogen mustard treated rats.

FIG. 4. Cancer cells in aortic blood of 2 rats with unresectable tumors. Solid line represents controls. Note presence of tumor cells before manipulation of tumor. About 2,800 cancer cells per cubic centimeter were found prior to manipulation. These cancer cells increased during manipulation procedures to about 4,500 and returned to the original count 5 minutes after manipulation. Dashed line, nitrogen mustard treated. Many cancer cells were found before manipulation of the tumor. When nitrogen mustard was administered the number of tumor cells decreased. Gentle massage later gave only a slight increase in tumor cells, much less than in the control. The decrease in the number of cells continued to decrease almost to zero at 30 minutes.

Survival and gross metastases (*Table II*). The following results were noted in this experiment in which nitrogen mustard was given.

Group 1.—No surgical or chemotherapeutic treatment was employed in this control group of 20 rats. The average survival time for this group was 2.9 weeks. None of these rats survived 9 weeks. Liver metastases were found in 25 per cent of the animals and lung metastases in 20 per cent.

Group 2.—In this group of 22 rats treated with nitrogen mustard, the average survival time was 5.1 weeks. None of the animals survived 9 weeks. Liver metastases were found in 18 per cent and lung metastases in 23 per cent of these animals. These results were not significantly better than the control group.

Group 3.—In this group of 80 rats in which resection was performed but no nitrogen mustard was given the average survival time was 4.7 weeks. Of this group, 19 or 24 per cent survived 9 weeks without recurrent disease. Liver metastases were found in 30 per cent, and lung metastases in 11 per cent of the animals at death or sacrifice.

Group 4.—In this group of 78 rats in which the tumor was resected and nitrogen

TABLE I.—PATHOLOGIC CONDITIONS OBSERVED IN FIRST STUDY

	Resectable				*Unresectable*	
	Group 1		*Group 2*		*Group 3*	
	No.	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*
Total No. of animals.	101		93		46	
Hepatic metastases..	29	29	13	14	8	17.3
Recurrence					not re-	
Primary site.....	24	24	17	18.3	sected	—
Wound.....	8	8	7	7.5	2	4.4
Survived 9 wks. without tumor...	25	25	31	33.4	—	—
Infection abscess....	12	12	11	12	1	2†
Peritoneal effusion..	8	8	15	16	10	22
Lymph node metastases.....	13	13	8	9	23	50

Group 1, manipulated; group 2 not manipulated.
Note that the recurrence rate at the primary site as well as the rate of metastases was greater in the manipulated group. Survival rate was lower then expected in the nonmanipulated group primarily because of the greater number with peritoneal effusion.

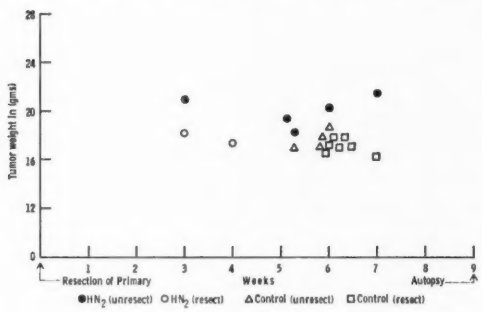


FIG. 5.

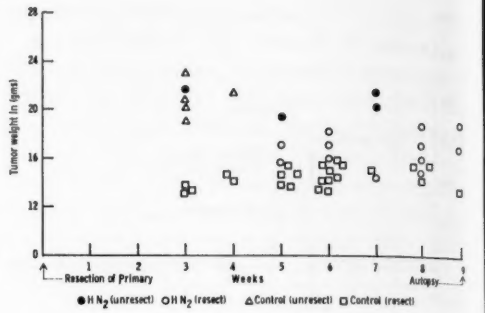


FIG. 6.

FIG. 5. Tumor weight related to time of occurrence of lung metastases in weeks.
FIG. 6. Tumor weight related to time of occurrence of liver metastases in weeks.

mustard was given, the average survival time was 5.8 weeks. Of the original 78 rats, 31 or 40 per cent survived 9 weeks without any observed recurrent or metastatic disease. In 11 of the 78 animals, or 14 per cent, liver metastases developed and in 2, or 3 per cent, lung metastases developed.

The use of nitrogen mustard in the resectable animals resulted in a significant decrease in both liver and lung metastases as well as in a longer survival.

There was no apparent correlation between the size and weight of the primary tumor and the time of occurrence of lung metastases (Fig. 5) or liver metastases (Fig. 6). Liver and lung metastases caused death most frequently between 5 and 7 weeks after resection.

When the results with the resectable and unresectable animals in the control and nitrogen mustard treated groups were combined the differences were less significant (Table III). However there was still a greater survival in the nitrogen mustard group, 31 per cent, compared to the controls, 19 per cent. Liver and lung metastases were also fewer in the nitrogen mustard group, 22 per cent, than in the controls, 40 per cent.

DISCUSSION

From the results obtained in this experiment it seems logical to suspect that the clumps of cancer cells released into the circulating blood at the time of manipulation play an important role in the dissemination of the disease. Cancer cells were demonstrated in the inferior vena cava and aortic blood at the time of manipulation in all resectable rats. Furthermore, the incidence of hepatic metastases was increased from 15 per cent in the nonmanipulated rats to 29 per cent in the manipulated group (Table III).

In a clinical study of 112 patients operated upon for cancer of the colon, Turnbull found that 28 per cent of the patients operated upon in the usual manner had tumor cells in the venous blood draining the tumor area, while 13 per cent of patients had such cells when manipulation was minimized during operation.

Even though large numbers of cells are found in unresectable animals these increase in number with manipulation. A surprise finding is the relatively small incidence of obvious metastases in the unresectable animals with large number of cancer cells in their blood. There are several possible explanations, obvious to us. The cells may continue to circulate until they die. Little is known of the survival time of tumor cells in the blood. The cells may lodge in capillaries and fail to grow or be fixed by fibrous replacement of the thrombus, or death of the animal may occur from the local tumor

growth before metastases have had a chance to develop.

It has been shown in a previous series of experiments that the circulating cells are viable. Blood taken from the vena cava and aorta of unresectable animals and injected subcutaneously in recipient animals has resulted in growth of solid tumors (3).

In the present experiments nitrogen mustard was effective in decreasing significantly the number of tumor cells in the unresectable animals. This effect lasted for more than 48 hours. Survival time was increased in the treated animals. In the resectable animals the direct effect of the nitrogen mustard on the tumor cells in the blood was not obvious. However, the survival rate at 9 weeks was increased from 24 to 40 per cent. Liver metastases were decreased from 30 per cent in the controls to 14 per cent in the treated and lung metastases were decreased from 11 to 3 per cent.

These results in experimental animals with a simulated cancer of the colon which rapidly metastasizes via the blood stream confirm the value of nitrogen mustard. Not only does it destroy cells in the circulating blood but it results in increased survival and a decrease in the metastases to liver and lung.

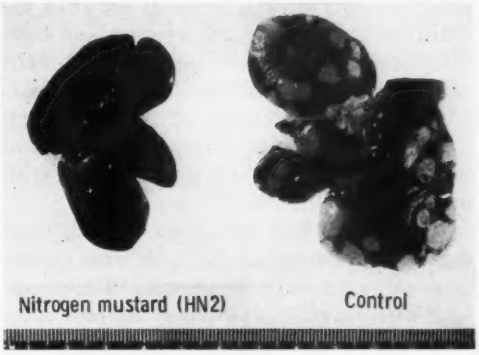
TABLE II.—RESULTS OF SECOND SERIES OF EXPERIMENTS

	Unresectable		*Resectable*	
	Group 1 Control	*Group 2 Nitrogen mustard*	*Group 3 Control*	*Group 4 Nitrogen mustard*
No. of rats	20	22	80	78
Liver metastases				
No.	5	4	24	11
Per cent	25	18	30	14
Lung metastases				
No.	4	5	7	2
Per cent	20	23	11	3
Free of disease at 9 weeks				
No.	0	0	19	31
Per cent	—	—	24	40

TABLE III.—NITROGEN MUSTARD TREATED GROUP COMPARED WITH CONTROLS

	Control	*Nitrogen mustard treatment*
Total	100	100
Pulmonary metastases	11	7
Hepatic metastases	29	15
Survived 9 wks. without metastases	19	31

Resectable and unresectable are combined.
Number of animals and per cent are the same since there were 100 animals in each group. Death in many animals was due to infection or to local tumor recurrence.



a b

FIG. 7. Autopsy specimens. a, Liver of a rat that was sacrificed at 9 weeks after receiving .04 milligram of nitrogen mustard per kilogram. b, Liver of a rat that died of multiple hepatic metastases.

This effect of nitrogen mustard on the rate of lung metastases is not unlike that reported previously for fibrinolysin and heparin (1, 6). With the latter agents, however, there is no direct antitumor effect but rather a prevention of lodging and growth of the tumor cells by the lysis or prevention of formation of fibrin. It is conceivable that a combination of nitrogen mustard or other chemotherapeutic agent with an anticoagulant or fibrinolytic agent in the presence of a resectable tumor may decrease still further the chance of development of metastases and ultimate failure of the procedure. Nitrogen mustard may also act by inducing fibrinolytic activity in vivo as many toxic substances do.

SUMMARY

1. A cecal tumor similar to a carcinoma of the colon in man can be produced in the rat with Walker 256 carcinosarcoma.

2. Massage of these tumors results in a shower of tumor cells in the general circulation. With resectable tumors no cells are

present prior to massage, and the cells remain for only a very few minutes and then disappear. With unresectable tumors, cells are present, increase markedly with massage, and then soon fall to the premassage level.

3. Nitrogen mustard decreases the number of cells present in the circulation with unresectable tumors.

4. Nitrogen mustard given prior to massage and removal of the resectable tumor causes a decrease in the number of liver and lung metastases.

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A CLINICAL STUDY OF ALCOHOLIC PANCREATITIS

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A CLINICAL STUDY has been continued of 127 patients in whom a diagnosis of alcoholic pancreatitis was made during the past 10 years in the hospitals with which we are or have been associated. A previous communication (10) described four etiologic varieties of pancreatitis which may be recognized by clinical study. These are pancreatitis associated with alcoholism, pancreatitis associated with gallstones, and pancreatitis associated with familial hyperlipemia or parathyroid adenoma. In the present article alcoholic pancreatitis is described as a definite clinical entity with a characteristic natural history and distinctive response to current surgical approaches.

In 1887, Friedreich wrote: "I am inclined to believe that general, chronic interstitial pancreatitis may result from excessive alcoholism (drunkard's pancreas)." Fitz, in 1889, agreed that many of the patients with pancreatitis whom he described "were addicted to the use of alcohol." Allen, in 1903, described a classical patient with alcoholic pancreatitis whom he cared for through two hospital admissions. The patient, a 30 year old woman who "was a drinker of alcoholic stimulants," suffered from diabetes, steatorrhea, a pseudocyst, and pancreatic calcification.

In 1917, Symmers, then the coroner of Dublin, Ireland, reported a group of 31 alcoholic patients, all of whom had died suddenly. In each instance, autopsy demonstrated acute hemorrhagic pancreatitis and no evidence of gallbladder disease. He wrote: "We have thus in these 31 cases a complex of alcoholic indulgence, sudden death, gastric hyperemia of a peculiar form and a necrotic condition of the pancreas. At present I refer to this condition as acute pancreatitis, probably due to alcohol."

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Supported in part by a grant from the U. S. Public Health Service.

NATURAL HISTORY

Alcoholic pancreatitis generally affects the individual in early adulthood. The disease most commonly occurs in the 20 to 40 year age group (Table I). There is generally little question of whether the patient is an alcoholic. Drinking usually begins when the patient is in the late teens or early twenties and continues habitually. It apparently matters little in what form alcohol is taken, but it usually includes whiskey and sometimes beer. Beer alcoholics are the few hearty souls who can stand volume as well as concentration, but voluminous daily intake is constant.

The "social drinker" is apparently unaffected. This observation also pertains to weekend drinking except in massive quantity although small amounts of alcohol may produce pain from an underlying chronic or recurrent pancreatitis.

After about 8 to 10 years of alcoholism, attacks of abdominal pain occur and become progressively more severe (Table II). A history of 5 and 10 hospitalizations of the patient with fully developed alcoholic pancreatitis is not unusual.

PATIENT 1. A 36 year old colored male alcoholic, an itinerant farm worker, was admitted to Hahnemann Hospital in September 1959 with severe abdominal pain following several days of an alcoholic spree. His history disclosed at least 17 hospital admissions for abdominal pain in 3 different cities since 1951. Seven of these admissions were to 1 hospital in Pittsburgh, where on 3 of these admissions, operation was performed. Exploratory laparotomy was the first operation. The second operation was cholecystectomy. A

TABLE I.—SEX RATIO AND AGE INCIDENCE IN PATIENTS WITH ALCOHOLIC PANCREATITIS

Investigator	*No. of patients*	*Men*		*Women*		*Av. age, yrs.*
		No.	*Per cent*	*No.*	*Per cent*	
Current series†	127	88	70	39	30	36
Bockus	31	21	68	10	32	40
Bell	25	16	64	9	30	41*
Clark	36	26	72	10	28	45
Longmire	7	7	100		—	39

*At time of death
†Includes 13 patients from a Veterans' hospital.

TABLE II.—CLINICAL FEATURES OF ALCOHOLIC PANCREATITIS

	No. of patients	*Per cent*
Total	127	100
More than 1 attack	102	86
Seen in early acute attacks	83	70
Incidence of gallstones	5	3.3
Pancreatic insufficiency—either exocrine and/or endocrine	41	35
Pancreatic calcification	61	51
Pseudocyst	21	18

choledochostomy with T-tube drainage—no common duct stones—was also performed. After 2 acute recurrences of pain, bilateral thoracoabdominal sympathectomy was performed. Pain continued to recur although the component of back pain disappeared.

Some of the many hospital admissions may be for abdominal pain and gastrointestinal bleeding. Since hyperamylasemia becomes progressively less prominent as the disease process progresses, the diagnosis of pancreatitis may be in doubt unless a history of recurrent attacks of abdominal pain and alcoholism is specifically sought. In other patients, alcoholic gastritis and acute hepatomegaly may account for some of the episodes of acute abdominal pain.

After several years of acute recurrent attacks of pain, the patient may then lapse into a stage of chronic abdominal and back pain with acute exacerbations.

Social and economic degradation occur gradually. Bouts of alcoholism, frequent hospitalizations, and the press of the expense of alcohol militate against vocational and marital stability. When chronic pain develops, narcotic addiction may begin. It is not unreasonable to suspect that the same personality factors operative in the etiology of alcoholism allow the alcoholic to espouse narcotic addiction. Patients known to have pancreatitis may severely tax the physician's judgment in his evaluation of pain of acute episodes once narcotic addiction occurs.

All of the variations in the severity of pancreatitis are observed. The disease may be acute. Both acute hemorrhagic pancreatitis and acute pancreatic edema have been observed in the alcoholic, and in 1 recent instance, almost complete pancreatic sequestration occurred. The attacks of pain become recurrent, and endocrine and exocrine insufficiency develop. The phase of chronic pain is reached in the end stage which is often characterized by pancreatic calcification, and overt chronic pancreatitis is then present.

Chronic pancreatitis, manifested by pancreatic calcification, is characteristic of alcoholic pancreatitis. Grossly the pancreas is nodular and firm with a characteristic gritty sensation when cut due to diffuse fibrosis and widespread pancreatic calculi (Fig. 1). Histologically, such a pancreas is laced with broad bands of fibrous tissue which isolate islands of pancreatic parenchyma in the interstices of these areas, a picture not unlike that of portal cirrhosis. Indeed, the picture is so similar to portal cirrhosis with its widespread fibrosis and irregular nodules of regenerating hepatic lobules that chronic pancreatitis may be spoken of as "pancreatic cirrhosis." Replacement of pancreatic acini by fibrous tissue may be evident (Fig. 2c). Pancreatic calculi may eventually develop throughout the entire gland; as a rule they are confined to the larger ducts, but calcium may be identifiable in the tiny ductules (Fig. 2a and b).

INCIDENCE OF PANCREATIC COMPLICATIONS

In approximately one third of the patients with acute and recurrent alcoholic pancreatitis pancreatic exocrine or endocrine insufficiency has developed. This condition may be associated with the appearance of pancreatic calcification.

Pancreatic calcification. To date, 61 patients with pancreatic calcification—not including 4 patients with carcinoma of the pancreas—

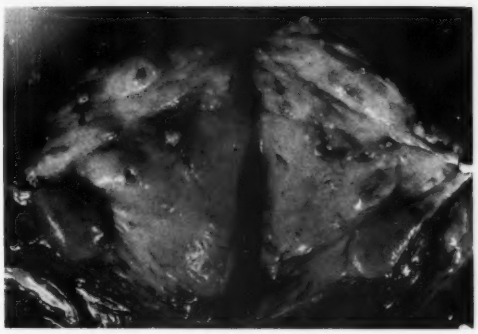
have been observed. Associated clinical findings were alcoholism in 90 per cent of these patients, gallstones in 4 per cent, recurrent pain in 92 per cent, and other pancreatic complications in 89 per cent. Pancreatic complications were diabetes in 37 per cent, steatorrhea in 32 per cent, and pseudocyst in 18 per cent. In an earlier study (15) of 32 patients found to have pancreatic calcification in a large charity hospital, all were alcoholics; 29 patients gave a definite history of recurring pancreatitis. Three additional patients with pancreatic calcification were found to have pancreatic carcinoma. In recurrent pancreatitis, the finding of pancreatic calcification is almost conclusive evidence that alcoholic pancreatitis has been or is present. Progressive pancreatic calcification, when it occurs in the alcoholic, may be observed over several attacks. In several instances, calcification was first seen in the head of the pancreas; subsequently the entire gland was involved in diffuse calcification (Fig. 3).

Diabetes. Secondary diabetes is a frequent, concurrent finding with pancreatic calcification, but it may occur in the precalcification state. Although the over-all incidence of diabetes was 22 per cent in the first 94 patients with alcoholic pancreatitis (10), the singular experience in an associated Veterans' hospital is interesting in this regard: Of 13 patients with alcoholic pancreatitis, 9 were frankly diabetic. Only 3 of these diabetics had pancreatic calcification.

In some instances, caprices of dietary and insulin intake in the irresponsible alcoholic render control difficult and admission to the hospital may then be for uncontrolled diabetes.

PATIENT 2. A 31 year old white female was seen in the accident ward. She was known to be an alcoholic and a diabetic, taking 45 units of NPH insulin daily. The immediate problem was diabetic coma and abdominal pain. Surgical consultation was requested because her family stated that sphincterotomy had been performed at another hospital. Routine scout film of the abdomen demonstrated no pancreatic calcification, but "coned-down" views of the pancreas demonstrated diffuse, fine pancreatic calculi.

a



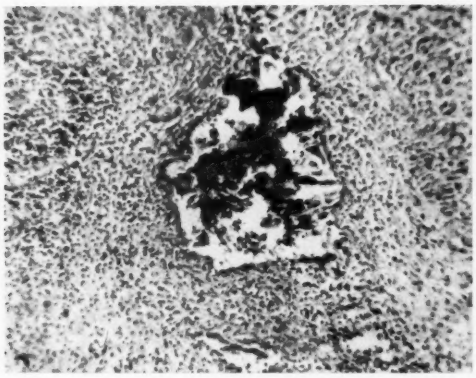
b

FIG. 1. Surgical specimen. Pancreatoduodenectomy for alcoholic pancreatitis with calcification. a, Dorsal surface. Probe is in the duct of Wirsung. b, Note the diffuse calcification and large calculi.

When the coma was under control, a history of repeated attacks of abdominal pain before and since sphincterotomy was obtained. Her serum amylase was within normal limits.

Though overt diabetes may not be present, diabetic glucose tolerance curves and hyperglycemia may be noted during an acute attack or during a quiescent stage (Fig. 4).

Steatorrhea. Steatorrhea is another common finding in chronic pancreatitis with calcification, having occurred in 21 per cent of the first 94 patients studied. Its presence with a noncalcified gland is also recognized. Latent defects of fat absorption may be detected without gross steatorrhea. In a few patients, steatorrhea will occur only during the acute attack. This may be the first clinical sign of



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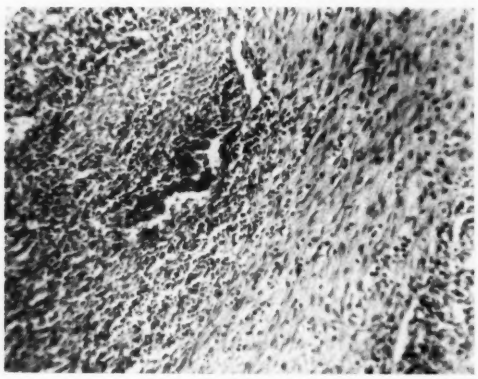

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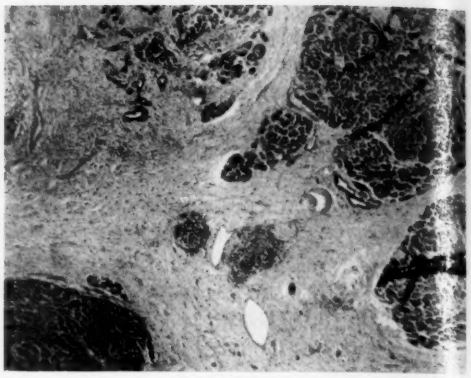


c

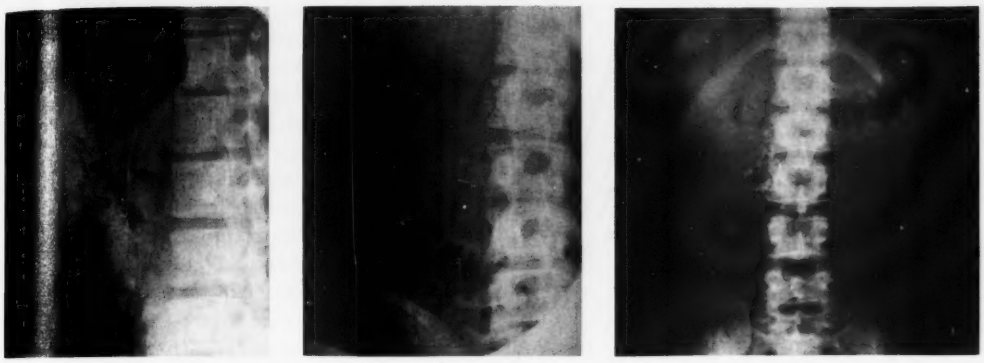
FIG. 2. Histologic sections of the same specimen as in Figure 1. Note deposition of calcium, a, within ductules; b, in the interstitial tissue. c, Diffuse fibrosis of the pancreas with fibrous replacement of acinar tissue.

exocrine insufficiency. As the attack subsides, steatorrhea may disappear until additional pancreatic injury occurs. Two recent patients with alcoholic pancreatitis in an acute episode were noted to have hyperlipemia. Pancreatic calcification was not present in either patient. The hyperlipemia resolved with subsidence of the acute attack. Though the significance of hyperlipemia in alcoholic pancreatitis is not known, this derangement of fat metabolism in the acute phase of pancreatitis may occasionally be observed.

Pseudocysts. Pseudocysts of the pancreas occurred in 21 of the patients with alcoholic pancreatitis. With the exception of pancreatic trauma, the pseudocyst results almost exclusively from pancreatitis. Varying degrees of pain are present which probably correlate with the severity and activity of the associated pancreatitis. Etiologic varieties of the underlying pancreatitis have not been recognized in the surgical literature on pseudocyst. In our experience, the pancreatitis which produces pseudocysts is of the alcoholic type.

The incidence of gallstones in alcoholic pancreatitis. Survey of the 127 patients with alcoholic pancreatitis has disclosed only 5 instances of gallstones. When "definitive" biliary tract operations were performed, the pain recurred in all 5 patients; that is, the course of the disease followed that of alcoholic pancreatitis with recurrence of pain in contradistinction to the relief of symptoms which occurs in uncomplicated gallstone pancreatitis. This singular absence of gallstones in patients with alcoholic pancreatitis and the failure to respond to operations on the biliary tract in the rare instance of gallstones with alcoholic pancreatitis serve to re-emphasize the fact that alcoholic and gallstone pancreatitis are different diseases.

The incidence of extrapancreatic complications of alcoholic pancreatitis. Concomitant disorders with alcoholic pancreatitis are frequent. In the group of 61 patients with alcoholic pancreatitis and pancreatic calcification, portal cirrhosis was present in at least 40 per cent, peptic ulcer in 12 per cent, esophag-



a b c

FIG. 3. Three scout films of the abdomen in a 32 year old colored male alcoholic with progressive calcification of the pancreas over a period of 6 years. Scout films were made on hospitalizations for acute, recurrent pancreatitis. a, Film of 1950, no calcification demonstrated. b, Film of 1952, calcification of the head of the pancreas. c, Film of 1956, diffuse calcification.

eal varices in 19 per cent and ascites due to cirrhosis in 12 per cent. Gastrointestinal bleeding in the alcoholic with pancreatitis may present a major differential diagnostic problem considering the coincident frequency of the number of possible lesions which could cause bleeding. On the other hand, the problem of gastrointestinal bleeding in the pancreatitis patient who has no varices, ulcer, gastritis, or tumor has received little attention in the literature. Massive gastrointestinal hemorrhage with pancreatitis has been variously ascribed to duodenitis, intrapancreatic bleeding, and circulating fibrinolysin. There are patients, however, in whom none of these mechanisms can be demonstrated.

PATIENT 3. A 38 year old colored male alcoholic was admitted to Hahnemann Hospital following repeated melena for 2 days prior to admission. Right upper quadrant and epigastric pain had been present intermittently for the previous year. His admission hematocrit was 22 per cent and his venous coagulation time, platelet count, and prothrombin time were all within normal limits. On the morning following admission, massive melena occurred. Exploratory laparotomy revealed pancreatic calcification and acute edematous pancreatitis. Liberal gastrotomy demonstrated no gastritis. Duodenotomy in the first and second portions of the duodenum demonstrated no ulcer or lesion of the ampulla. Blood could not be demonstrated to exude from the ampulla with pressure on the pancreas or common duct. The remainder of the small bowel and colon appeared free of disease. Convalescence was uneventful. There has been no recurrence of melena in the year after operation although alcoholic intake continues.

The response of the patient with alcoholic pancreatitis to operation. In another report (11) an outline of modern operative procedures for pancreatitis was compiled. If only those procedures which are designed to ameliorate the pain of pancreatitis are considered, at least 16 operations have been described and applied to this problem. Results of 57 indirect procedures in alcoholic pancreatitis are tabulated in Table III. The most significant observation is the almost invariable poor response to biliary tract operations in alcoholic pancreatitis. It is believed that this singular lack of response to operations on the biliary tract serves as the hallmark of alcoholic pancreatitis and sets it apart from gallstone pancreatitis which has an almost invariably excellent response to biliary tract surgery. It should be pointed out that Bowers and Riley have followed up alcoholic patients treated by choledochojejunostomy and their results have been better than those of the current series.

Direct pancreatic procedures in alcoholic pancreatitis are currently being evaluated.

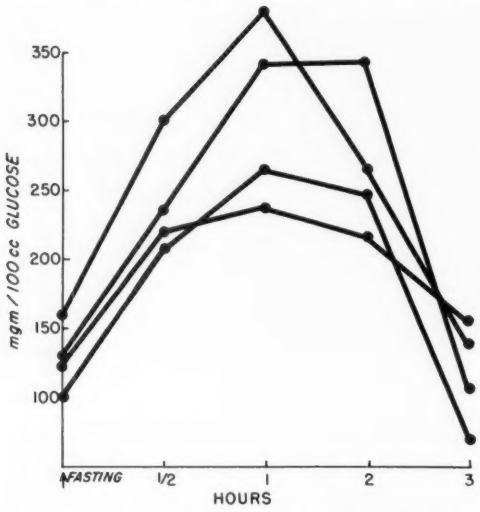


FIG. 4. Oral glucose tolerance curves of 4 patients with recurrent alcoholic pancreatitis following subsidence of an acute attack. Diabetes was not recognized prior to or in the interim between acute attacks.

Jordan and Howard abandoned, for the present, distal pancreatectomy with retrograde pancreatojejunostomy in the treatment of alcoholic pancreatitis after 5 of 6 such patients probably suffered recurrences within 1 year. DuVal's results with the operation have encouraged him to continue its application (6,7). Jordan and we have abandoned total pancreatectomy for alcoholic pancreatitis because the alcoholic will not care for the resultant diabetes.

TABLE III.—RESPONSE OF ALCOHOLIC PANCREATITIS TO OPERATION

	No. of operations	*Failures*
Operations on the biliary tract		
Cholecystectomy (noncalculus)	21	19
Cholecystectomy (calculus)	2	2
Cholecystostomy	8	8
Choledochostomy and T-tube drainage	1	1
Choledochojejunostomy		
Obstruction of the common duct due to pericholedochal (pancreatic) fibrosis	4	0
Recurrent pain. No common duct obstruction	4	3
Cholecystojejunostomy	8	7
Sphincterotomy	9	7
Total	57	47
Pancreatic operations		
Caudal pancreatojejunostomy (15)	6	5
Subtotal (Whipple) pancreatectomy	5	0
Other operations		
Thoracolumbar sympathectomy	2	2
Total	70	54

Pancreatic duct lithotomy with sphincterotomy or with ductal enteric anastomosis has been suggested by Warren and Cattell for chronic calculus disease of the pancreas. In a pancreas with calcification throughout its entirety and with tiny intraductal calculi, removal of the largest calculi would seem to offer little promise of success. It is believed that pancreatic calculi are the results rather than the cause of alcoholic pancreatitis.

Pancreatoduodenectomy for alcoholic pancreatitis is being evaluated in this and other institutions. Although the indications for an operation of this magnitude are not clear, initial results with 5 successive patients are encouraging.

PROGNOSIS

With the onset of alcoholic pancreatitis, recurrent attacks are the rule as long as alcoholic intake persists. Experience with withdrawal of alcohol is limited, for the patient seldom stops drinking. Over half of the patients develop stigmas of chronic pancreatic disease by the development of pancreatic calcification, diabetes, steatorrhea, and pseudocysts.

Alcoholic pancreatitis in the acute phase has been fatal for 8 of 83 patients; in the chronic stage it has been responsible for death in 16 of 44 patients. Seven deaths resulted from other causes. When the disorder becomes chronic, complications of diabetes and nutritional deficiencies may be sources of mortality. Unembellished alcoholism may contribute to mortality through traffic accidents, subdural hematomas, and fractures of long bones. A survey of 32 patients with pancreatic calcification secondary to alcoholic pancreatitis demonstrated that the median age of death was 45 years.

SUMMARY

Alcoholic pancreatitis appears to be a distinct clinical entity. It affects chiefly younger men. Initially the disease is charac-

terized by intermittent, acute attacks, any one of which may be fatal. Subsequently the course is marked by chronicity as the pancreatic parenchyma is replaced by fibrous tissue. "Pancreatic cirrhosis" leads to diabetes, steatorrhea, and calcification. Pseudocysts are not infrequent.

The response to indirect surgical procedures has been so disappointing that their utilization should be carefully reappraised.

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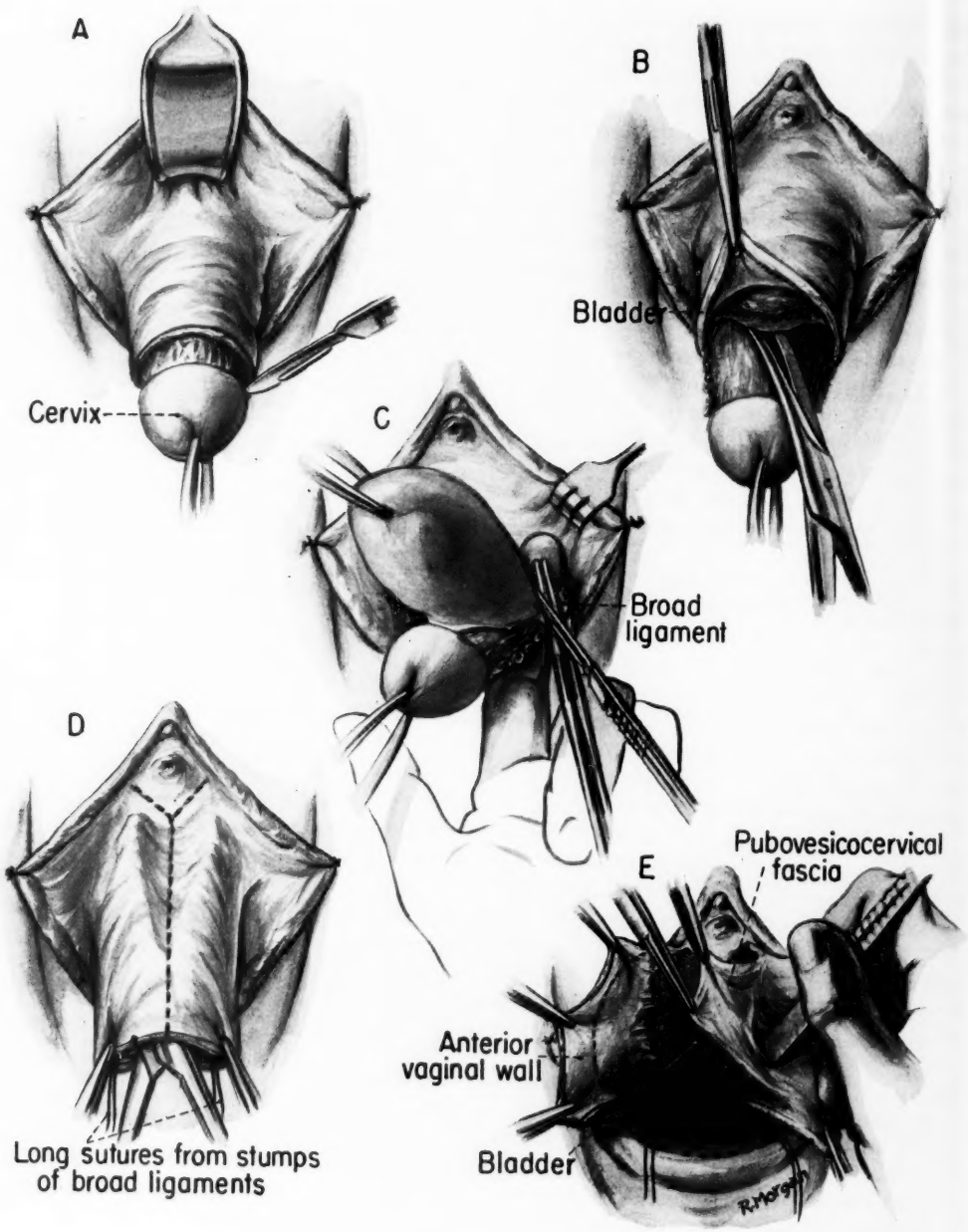

FIG. 1.

Total Colpectomy.—Nelson M. Percy and John I. Perl.

TOTAL COLPECTOMY

NELSON M. PERCY, M.D., F.A.C.S., and JOHN I. PERL, M.D., F.A.C.S., Chicago, Illinois

COMPLETE UTEROVAGINAL PROCIDENTIA is so disabling that the patient and her physician are forced to take any steps which will give reasonable assurance of a cure. Percy resorted to vaginal obliteration in 1924 for the relief of complete or nearly complete genital prolapse. From 1 January 1924 to 31 December 1958, 315 patients submitted to this procedure at Augustana Hospital. A review of the world literature for the past 135 years indicates that this series of total colpectomy and panhysterocolpectomy exceeds the total reported to date.

The first total removal of the vagina was probably performed by Simon (17, 18, 19) for the cure of a large vesicovaginal fistula. How complete the "total" vaginectomy was is not clear from his report.

Priority for the complete removal of the uterus and the vagina for the correction of prolapse belongs to Martin who in 1894 first performed a vaginal hysterectomy, excised the vagina, and sutured the pelvic peritoneum and stumps of the broad ligaments to the introitus at the level of the carunculae myrtiformes. He narrowed the introital segment by means of a deep circular stitch placed where the peritoneum had been anchored to the caruncular ring. He made no further attempt to close the defect left by excision of the vagina. Edebohls in 1901 published the first well documented case reports of complete vaginal obliteration after "panhysterocolpectomy" (7, 8). He extirpated the uterus and vagina and closed the raw channel with 5 to 8 purse-string catgut sutures, "columnizing" the denuded vaginal tract. Thus, while priority belongs to Martin for the concept of treating uterovaginal procidentia by excision of the uterus and vagina, credit for the logical completion of the operation by primary suture obliteration of the defect between the pelvic floor and vulva belongs to Edebohls.

Panhysterocolpectomy was resorted to sporadically by Edebohls (7, 8), Gallant (9, 10, 11), Waldo, and others up to 1911. Edebohls' work was ignored until Masson and Knepper referred to it in 1938. Total colpectomy with columnization of the vaginal tract was described as a new operation as late as 1951 by Adams. Erroneously, Phaneuf (14) gave Dujarier and Larget credit for originating the procedure.

Approximately 81 modified Edebohls' operations for complete vaginal obliteration after removal of the uterovaginal unit were reported by Delivet, Desmarest (4, 5), Bergeret and others to 1932. These are not to be confused with various modifications of the Peter Muller operation in which the vagina is partly or completely removed and the uterus with or without the cervix is left in situ. These French surgeons improved on the Edebohls procedure in that they obliterated the denuded vaginal tract with interrupted sutures placed in the levator ani and closed the introitus in the anteroposterior line. They did not repair the cystocele. Rouhier in 1940 (16) allowed correction of the bladder prolapse to depend on a line of interruptured sutures between the bladder and rectum without imbricating stitches in the vesicle fascia.

Sporadic cases and a small series of hysterectomy with pancolpectomy were reported in the American literature between 1911 and 1936. Although employed by others for many years and employed in the series here reported since 1924, simultaneous repair of the cystocele in panhysterocolpectomy was first reported by Masson and Knepper in 1938 in 38 total vaginectomy

Dr. Nelson M. Percy is now deceased.

From the Augustana Hospital, Chicago. Supported by funds from the Nelson M. Percy Medical Research Foundation of Augustana Hospital.

TABLE I.—CHRONOLOGIC DISTRIBUTION OF TOTAL COLPECTOMY ACCORDING TO NUMBER OF OPERATIONS PERFORMED PER YEAR AND IN 5 YEAR PERIODS

						Totals, 5 year periods
Year.....	1924	1925	1926	1927	1928	
No.....	2	1	3	1	3	10
Year.....	1929	1930	1931	1932	1933	
No.....	9	12	16	11	13	61
Year.....	1934	1935	1936	1937	1938	
No.....	15	4	10	8	14	51
Year.....	1939	1940	1941	1942	1943	
No.....	6	14	16	12	13	61
Year.....	1944	1945	1946	1947	1948	
No.....	14	17	12	14	11	68
Year.....	1949	1950	1951	1952	1953	
No.....	7	11	7	2	6	33
Year.....	1954	1955	1956	1957	1958	
No.....	7	5	2	10	7	31

operations for procidentia. The Masson and Knepper 1938 report was followed by articles by Svesko, and by Williams who reported 60 cases, and by Adams, and Ricci and Thom.

DEFINITIONS

In this presentation the term "total genital prolapse" is applied to complete eversion of the vagina with the uterine cervix at the apex of the prolapsed structures. "Complete vaginal prolapse" is applied to the totally everted vagina after total hysterectomy.

In our opinion, complete eversion of the vagina that develops after either total hysterectomy or supracervical hysterectomy is inevitably accompanied by an enterocele of some degree.

The term "near-complete genital or vaginal prolapse" is used when a minor part of the vaginal wall is not everted.

The term "total vaginectomy" is applied in the strictest sense to the removal of the entire vagina with the exception of an approximately 1.5 centimeter triangular piece of the carina urethralis vaginae

CLINICAL MATERIAL

These 315 complete vaginal obliterations were performed on private patients in the Augustana Hospital, Chicago. Ninety-seven patients had been subjected to one or more gynecologic operations prior to the vaginal obliteration. The total of admissions to Augustana Hospital from 1 January 1924 to 31 December 1958 was 260,365. Total vaginal obliteration was performed on approximately 0.12 per cent of patients admitted or 0.8 per cent of the gynecologic patients admitted.

AGE

Two patients were younger than 40 years of age. One was 32 years old, para 6, suffering from diabetes, hypertension, and a 7.5 centimeter endometrial polyp; the other was 39 years old, para 2, found to have mitral stenosis. The oldest was 92 years of age. One hundred and sixty-five patients, 52.4 per cent, were between 60 and 69 years old; 83, 26.3 per cent, between 50 and 59, and 7, or 16 per cent, in the age group of 70 and 79 years. The average was 63.5 years.

Of the 315 patients, 241, or 76.5 per cent, were operated upon between 1 January 1929 and 31 December 1948 (Table I). Three patients were nulliparous. The 278 patients had borne 1,462 children; 155 had borne 5 or fewer children; 120 patients had 6 or more children, and, among these, 30 had more than 8. Thirty-seven records contained no information as to parity.

COEXISTING DISEASES

Patients with an average age of 63½ years have a high incidence of significant coexisting disease. In this series cardiovascular disease, obesity, goiter, diabetes, and gallbladder disease occurred in that frequency.

There were 111 cases of cardiovascular disease; 67 of obesity; 10 of diabetes; 16 of nodose goiter; 2 of thyrotoxicosis; 10 of cholelithiasis; 1 of carcinoma of the rectum; 2 of duodenal ulcer; 3 of bronchial asthma; 2 of inguinal hernia; 1 each of umbilical and femoral hernia; 2 of rectovaginal fistula; 1 each of vesicovaginal fistula, bladder stone, tumor of the tonsil, and colitis; 35 of varicose veins; 16 of hemorrhoids; and 1 of herpes zoster.

It is assumed that complete vaginal prolapse, in the absence of the uterus, will inevitably be accompanied by a peritoneal sac containing bowel. Therefore, an enterocele would be part of the 47 such prolapses in this series.

The mass prolapsing through the vulva, which made sitting and walking difficult, caused these patients to seek medical help. They also complained of a feeling of fullness, frequency of urination and incontinence of urine, inability to empty the bladder, constipation, spotting or bleeding due to ulceration of the prolapsed part, and backache.

Prolapsed cervices are the seat of significant, usually ulcerative, cervicitis as well as some degree of keratosis and parakeratosis. One and four-tenths per cent of all cervices showed carcinoma; in situ in 1 instance and infiltrating in 3. There were 3 patients (1.1 per cent) with carcinoma of the body of the uterus; 1 carcinoma of the ovary; 1 Brenner tumor accompanying a carcinoma of cervix; 1 adenocarcinoma of the rectum; 18 cervical polyps; 12 cases of polypoid hyerplasia of the endometrium; 38 endometrial polyps; 8 cases of endometriosis; 54 fibromyomas; and 1 bladder stone.

Thirty of the 315 patients, on whom total colpectomy was performed, had previously been subjected to total hysterectomy; 17 had previously been subjected to supracervical hysterectomy.

The entire uterus was available for study in 268 cases. Eight carcinomas were found among them. They included 1 carcinoma in situ and 3 early infiltrating carcinomas of the cervix and 3 carcinomas of the body. No significant disease was found in the 17 prolapsed cervical stumps. This incidence of carcinoma of the cervix is sizable in the face of the widespread belief that malignancy is rare in the prolapsed cervix.

Uterine cancer was present in 7 of 285 patients (2.45 per cent); total genital cancer was present in 8 instances (2.8 per cent). Of these, 7 were uterine and 1 was ovarian in location. The total number of instances of cancer in 315 patients was 9 (2.8 per cent) and of these, 7 were uterine, 1 ovarian, and 1 was a rectal cancer.

TABLE II.—POSTOPERATIVE COMPLICATIONS

Complications	*No. of cases*		*Outcome*
Urinary		22	
Cystitis	12		
Vesical hemorrhage	1		
Urinary incontinence 27 days	1		
Urinary obstruction up to 12 days	5		
Pyelitis	3		
Cardiovascular		15	
Coronary occlusion	5		3 died
Thrombophlebitis	4		Recovered
Pulmonary embolism	5		3 died
Postoperative shock	1		Recovered
Abscess		7	
Perirectal	1		Recovered
Pelvic, local peritonitis	2		Recovered
Perineal	2		Recovered
Abdominal wall	1		Recovered
Carbuncle of elbow	1		Recovered
Pneumonia		1	Died
Rectal fistula		1	Recovered
Dementia precox		1	To mental institution
Intermittent diarrhea		1	Recovered
Ileus, 2 weeks' vomiting		1	Recovered
Acute cholecystitis		1	Recovered
Anovulvar pain 11 to 16 days		3	Recovered
"Stupor" and fever		1	Died

The incidence of leukoplakia and hyperkeratosis of varying degree is not recorded, because all prolapsed cervices undergo some degree of cornification and keratinization. The average area of the excised vaginal integument in the 28 cases in which it was measured was approximately 100 square centimeters.

POSTOPERATIVE COMPLICATIONS

Fifty-one per cent of the patients had a temperature of 100 to 101 degrees F. for several postoperative days. Urinary and cardiovascular incidents were the most frequent postoperative complications. There were 7 abscesses, 6 adjoining the surgical field, 1 a carbuncle of the elbow as indicated in Table II.

MORTALITY

There were 8 deaths among the 315 patients on whom complete vaginal obliteration was performed, a 2.5 per cent mortality (Table III). Coronary occlusion caused the death of 3 patients, 1 each on the eighth,

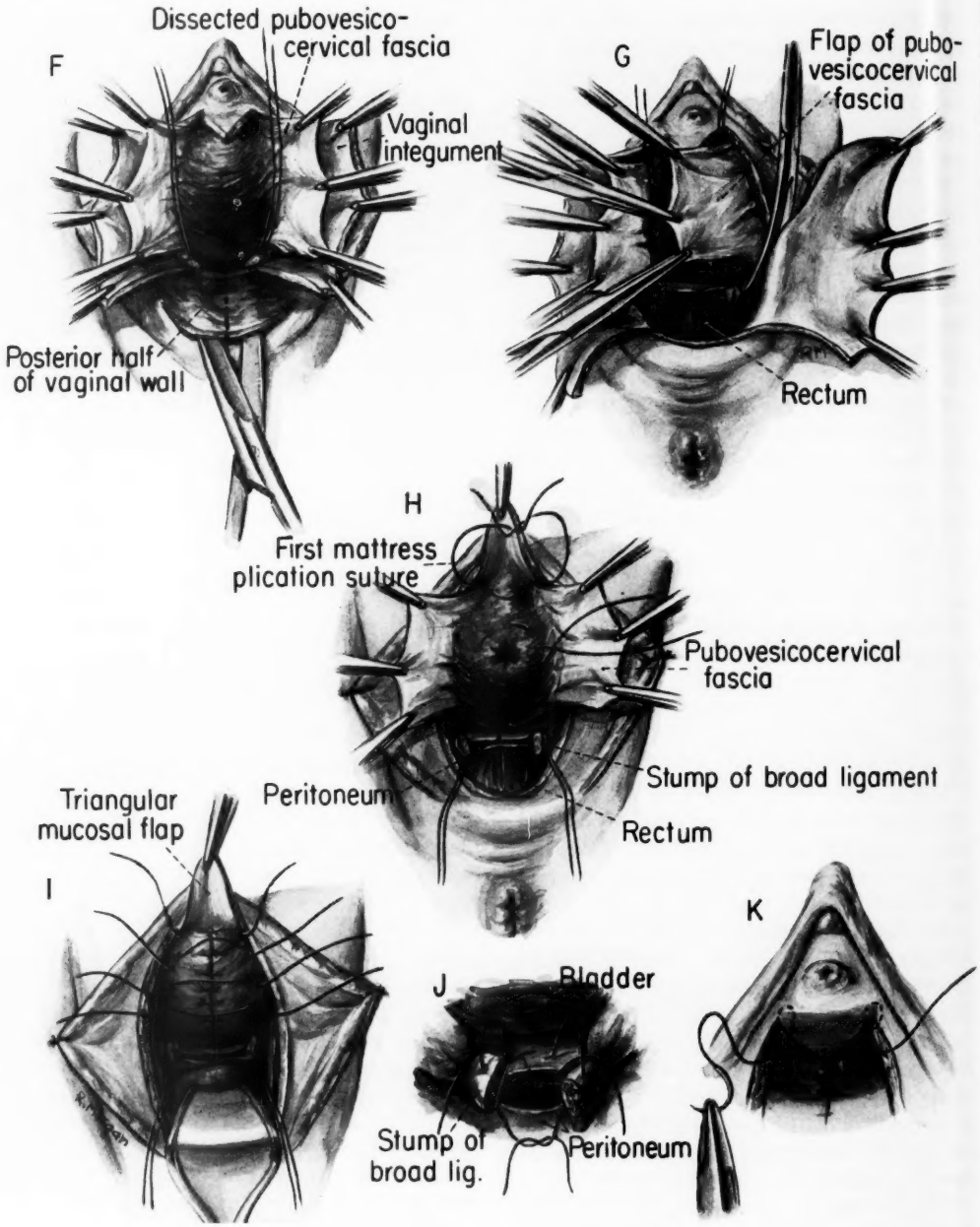
F
Dissected pubovesico-cervical fascia
Vaginal integument
Posterior half of vaginal wall
G
Flap of pubo-vesicocervical fascia
Rectum
H
First mattress plication suture
Pubovesicocervical fascia
Stump of broad ligament
Rectum
Peritoneum
Triangular mucosal flap
I
J
Bladder
Stump of broad lig.
Peritoneum
K

FIG. 2.

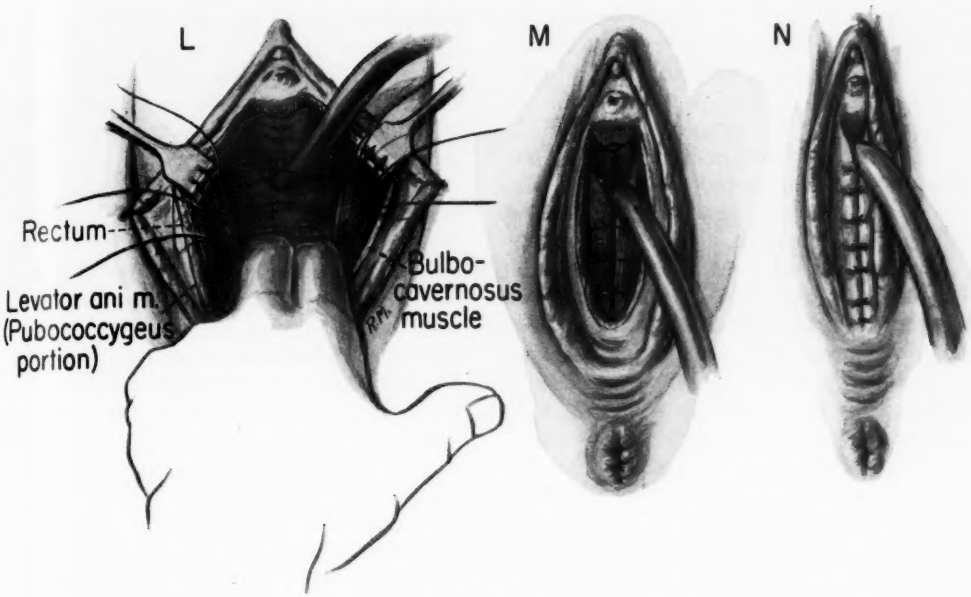

FIG. 3.

twenty-second, and twenty-fourth postoperative days. Three patients died from pulmonary embolism on the eleventh, fifteenth, and eighteenth postoperative days. One patient, suffering from a carcinoma of the rectum infiltrating the prolapsed vagina, was subjected to a Kraske operation and panhysterocolpectomy. She died on the thirty-third postoperative day from pneumonia in 1930. A 68 year old patient died on the seventh postoperative day in stupor and with a high temperature; an autopsy was not obtained. The last death occurred in 1945; since then, 106 patients have been subjected to a total colpectomy without a death.

Of the 315 patients 307 left the hospital fully recovered with the operative field well healed. The average duration of hospitalization was 26 days. The follow-up studies have been limited. However, not a single recurrence was observed or reported by the attending or referring physician among the 307 patients who left the hospital recovered. Without qualification, those relieved of the burden of a major genital prolapse by complete vaginal obliteration are the most grateful of patients.

TECHNIQUE

The stages of the procedure consist in: (1) vaginal hysterectomy or excision of the cervical stump, if there has been previous supracervical hysterectomy; (2) excision of enterocele if present; (3) total vaginectomy; (4) repair of cystocele by imbrication of the pubovesicocervical fascia; (5) closure of the peritoneum and suture of the stumps of the cardinal ligaments; (6) suture of levator ani and perineal muscles; and (7) closure of introitus.

In preparation of the patient, edema, if present, is treated with sitz baths, mild antiseptic douches, and bed rest for several days with the prolapsed parts replaced; urinary bladder infection, if present, is controlled; and the operative field is prepared with a surgical scrub and the vagina is painted with a suitable antiseptic.

The following technique, used since 1924,

has been subject to minor variations dictated by distortions induced by previous operation. The bladder is emptied by catheter, and its position in relation to the prolapsed uterus or cervix is determined with the aid of a uterine sound or metal catheter. The labia minora are sutured to the skin laterally under tension, producing transverse gaping of the introitus.

The majority of the patients are elderly, the uterus is atrophic, and the cervix is elongated and thinned to 1.5 centimeters or less in diameter. This attenuated cervix is covered by cystocele. It is often difficult to distinguish between the two. To prevent injury to the bladder a single hook is introduced into the cervical canal through the external cervical os. The cervix is pulled sharply downward by means of the hook. The redundant bladder is displaced toward the uterine fundus by a massaging and sweeping motion of the index finger and thumb as anterior and posterior retractors take up the slack in the vaginal wall over the bladder and rectum, putting the tissues under maximal tension. The bladder having been safely displaced, the portio is grasped with a vulsellum and the single hook is removed.

The reflection of the vagina onto the cervix is kept under tension by pulling the portio sharply downward as the anterior half of the cervicovaginal junction is divided. The posterior half is incised while the portio is pulled upward over the symphysis. This traction causes wide separation of the incised layers (Fig. 1A). The vesicovaginal space, the paravesical spaces, and the rectovaginal space are exposed. Unless pre-existing scars interfere, the vagina is readily separated from the cervix by wiping toward the fundus with the gauze-covered finger. The vaginal circumcision having been completed, the fibers of the "cervicovaginal septum" are divided transversely, the vesicocervical space is entered, and the bladder is swept toward the fundus until the vesicouterine fold of the peritoneum is visualized and opened. The cervix is elevated sharply toward the symphysis, the incised posterior fornix is swept toward the fundus, the peritoneum of the posterior cul-de-sac is identified and opened, and the index and middle finger are introduced into the pelvis to explore the fundus and adnexa.

Digital exploration having been completed, the tip of the index finger remains in the cul-de-sac. It is hooked around the sacrouterine and cardinal ligaments, first on one side and then on the other, as the cervix is elevated, putting these ligaments under tension, and hemostats are applied to them. They are clamped up to but not including the uterine arteries, divided, transfixed, and ligated, leaving a generous stump proximal to the ligatures. The index finger now identifies the uterine vessels contained in the intact segments of the cardinal ligaments. They are doubly clamped, divided close to the uterus, and doubly ligated. The uterine fundus is drawn through either the opened anterior (Fig. 1C) or posterior cul-de-sac incision, and the remainder of the broad ligaments, fallopian tubes, round ligaments, and utero-ovarian ligaments are doubly clamped, divided, and ligated and the uterus is removed. Long suture ligatures are left attached to the ends of the ligaments for later use.

This vaginal hysterectomy is easy to perform unless scar tissue and adhesions distort anatomic relations.

Vaginectomy. The long suture ligatures on the stumps of the broad and round ligaments hang with forceps clamped to their free ends. The circumcised edges of the vagina are grasped with forceps and the vagina is everted with maximum tension applied to its anterior wall. The vesicovaginal space is entered with curved scissors, and the vaginal wall is separated from the bladder by blunt scissors dissection (Fig. 1D). Vaginal integument so mobilized is divided lengthwise in the midline to within 1 or 1.5 centimeters of the external urethral meatus. Here the sole remnant of the vagina is a V-shaped shield attached to the posterior aspect of the terminus of the urethra (Fig. 1D). After bi-

TABLE III.—POSTOPERATIVE DEATHS

Year of operation	*Age, years*	*Operation*	*Postoperative day of death*	*Cause*
1945	69	Vaginal hysterectomy and obliteration	18	Pulmonary embolism
1942	61	Vaginal hysterectomy and obliteration	15	Pulmonary embolism
1939	68	Vaginal hysterectomy and obliteration	7	High temperature, stupor, from day of operation
1933	58	Vaginal hysterectomy and obliteration	11	Pelvic phlebitis, pulmonary embolism
1932	63	Vaginal hysterectomy and obliteration	22	Coronary embolism on 6th and 17th postoperative days
1931	55	Vaginal hysterectomy and obliteration	24	Coronary embolism
1930	58	Kraske bowel resection for cancer of rectum and vaginal hysterectomy and obliteration	33	Pneumonia
1928	71	Vaginal hysterectomy and obliteration	8	Coronary occlusion—cardiac dilatation

section of the anterior vaginal wall, forceps are placed (Fig. 1E) on the edges of the vaginal flaps, and the dissection is carried bilaterally so that the anterolateral vaginal walls are freed from their attachments. At this point the pubovesicocervical fascia is dissected with care from the vaginal flaps for later imbrication posterior to the bladder. This dissection is accomplished with the vaginal flaps under the even tension of forceps at 2 to 3 centimeter intervals along the entire flap edge (Fig. 1E). The fascial margin, similarly secured with forceps along a curved incision, is separated from the tautly held vaginal integument by sharp and blunt dissection (Fig. 1E). The cleavage plane between the vaginal wall and fascia is first followed laterally, then upward and laterally to its pubic attachment. This dissection, although occasionally time-consuming, presents no difficulties. It frees sufficient fascia from each vaginal flap to make imbrication and plication possible.

After the pubovesicocervical fascia has been dissected free, the dissection of the anterior vaginal flaps may be continued into the posterior vaginal wall, detaching the entire vaginal integument in one piece from the rectum. However, circumstances often make it simpler to begin the posterior dissection with a curved incision (Fig. 1E, lower dotted line) along the fourchette, separating the vaginal wall from the rectum by blunt, curved scissors dissection in the midline. The freed vaginal wall is then divided sagittally, the cut edges are grasped by forceps, and the flaps dissected laterally until both halves of the vagina have been detached (Fig. 2G and H). Excision of the vaginal wall leaves a large defect. Significant bleeding from this raw surface is controlled with ligatures. Part of a large gauze pad, omitted from the illustration, is inserted into the abdomen through the opening in the pelvic peritoneum, to prevent loops of bowel from sliding into the operative field, and the remainder of the pad is pressed down on the rectum with a long retractor to control oozing and to give better exposure for the repair of the cystocele, the lower half of which hangs without support beneath the symphysis.

The first step in closing the defect and in correcting the position of the bladder is the placement of several purse-string sutures in the bladder fascia to invert and so reduce its prolapsed parts. These are followed by a row of Kelly type plicating mattress sutures under the urethra and bladder neck to narrow the former and to tighten the vesical sphincter (Fig. 2H). Imbrication of the pubovesicocervical fascial flaps is followed by a second and third superimposed row of plicating mattress sutures until the urinary

bladder has been advanced behind the symphysis (Fig. 2H and I). With the bladder firmly supported in place by the imbricated and plicated pubovesicocervical fascia, the gauze pad is removed from the pelvis and vaginal tunnel. By use of the long catgut sutures attached to them, the stumps of the broad ligaments are sutured together and the peritoneum is closed around a Penrose drain (Fig. 2J, drain not shown). The triangular remnant of vaginal integument, posterior to the urethral orifice, is brought into position as a supporting shield for the distal urethra by means of a Kelly suture (Figs. 2K and 3L). The Penrose drain, whose tip is within the pelvis, is held against the base of the bladder and symphysis by a narrow retractor. Four or 5 deeply placed interrupted sutures now unite the levators in the midline, the rectum being held down with the operator's middle and index fingers. Oozing of blood is stopped and a few additional sutures unite the bulbocavernosus and perineal muscles in the midline, leaving only the integument of the introitus to be closed by a continuous catgut suture (Fig. 3L, M, and N).

If the uterus has been removed by total or supracervical hysterectomy on some previous occasion, the initial step of the colpectomy consists in excision of the scar at the apex of the vagina or excision of the cervix, as the case may be. Vaginectomy is then carried out as described.

If a significant enterocele is present, the peritoneal sac is excised.

DISCUSSION

The epithelial coverings of surfaces and cavities serve many functions. Important among them is the maintenance of the patency of hollow organs whose walls will fuse if deprived of their epithelium. Thus, if the vaginal epithelium is completely removed, the resultant raw surfaces will fuse, and scar tissue will obliterate the vaginal canal. The success of complete colpectomy in the treatment of major genital procidentia rests upon this fact. The various techniques for partial colpectomy provide a ribbon, plate, or diaphragm type of obstruction to the forces that push the urinary bladder, thrust the wedge-like uterus, and nudge the anterior rectal wall into and beyond the vulva. The compromise, inherent in partial colpectomy for major prolapse, has an appreciable recurrence rate as evidenced by reports in the literature. Total removal of the vaginal integument and extirpation of the uterus eliminate the downward drag of the uterus and permit the full length obliteration of the vagina with well anchored scar tissue. This procedure is not followed by recurrence.

The panhysterocolpectomy provides optimal exposure for the repair of the cystocele, for the adequate suture of the levator muscles, and for the reconstruction of the urogenital diaphragm. It also removes the danger of hydrometra and pyometra and of malignancy, present or future, in a retained, buried, nonfunctional uterus.

Although panhysterocolpectomy is an involved procedure, the morbidity and mortality rates of this series compare favorably with the morbidity and mortality reported after partial colpectomy, colpocleisis, and the Peter Muller type procedures. Six of the 8 deaths in this series resulted from acute coronary occlusion or pulmonary embolism, complications equally likely to follow partial colpectomy. The seventh death was caused by pneumonia on the thirty-third postoperative day after a panhysterocolpectomy and resection of the rectum for rectal carcinoma invading the prolapsed vagina.

On the other hand, as would be expected, the incidence of urinary tract complications after panhysterocolpectomy was higher than that after purely vaginal procedures. These complications were transient, requiring no surgical intervention, and all patients had fully recovered during the period of hospitalization. Five of the 8 deaths occurred before 1934. Among the last 106 patients treated between 1945 and 1958 there were no deaths.

There is a widespread belief that carcinoma is rare in the prolapsed cervix. Four carcinomas were present in 268 prolapsed cervices, 2 of which were so inconspicuous as to be first detected by histologic examination. In addition, 3 endometrial carcinomas and 1 ovarian carcinoma occurred in this series. Exfoliative cell diagnosis will rule out the majority of clinically imperceptible carcinomas of the uterus. Removal of the uterus has the added advantage over those techniques which leave it in place, in that all present and future cancers of this organ are obviated. An 18 per cent incidence of endometrial polyps and endometrial hyperplasia in the 268 uteri are indicative of continued endometrial activity in spite of the age of these patients.

The last point to be considered in weighing the more radical against the less radical procedures is the status of the copulation faculty. Some proponents of modifications of the Neugebauer-LeFort and Peter Muller procedures emphasize the preservation of a vaginal pouch for coital purpose. In our opinion, a compromise procedure, though carrying a significant danger of recurrence, should be carried out in lieu of the optimal procedure, vaginal obliteration, for those patients to whom sex relations are important. However, patients with a complete or near complete genital prolapse are, as a rule, so miserable that they rarely object to the loss of a function which they, in most instances, no longer possess. Furthermore, the type of intercourse for which an approximately 1 inch deep vaginal pouch is preserved probably can be accomplished without the utilization of such a shallow receptacle.

SUMMARY

1. Between 1924 and 1958, 315 patients suffering from major genital prolapse were treated at the Augustana Hospital by complete vaginal obliteration. Complete colpectomy was performed on 30 of these patients who had previously been subjected to total hysterectomies. Excision of the cervical stump and complete colpectomy was performed on 17 patients who had previously been subjected to supracervical hysterectomy. Panhysterocolpectomy was performed on 268 patients in whom the uterus was present.

2. Cystocele repair was achieved by imbrication of the pubovesicocervical fascia. The levators, perineal, and bulbocavernosus muscles were sutured together.

3. The patients ranged in age from 32 to 92 years. Their average age was 63½ years; the average parity was 5.2.

4. Seventeen per cent of the patients suffered from significant coexisting disease at the time of operation.

5. The mortality for the series was 2.5 per cent. The causes of death were coronary occlusion in 3, pulmonary embolism in 3, and pneumonia in 1; the cause was not determined in 1.

6. Four cervical carcinomas and 3 endometrial cancers were found incidentally in the 268 excised uteri. No malignant lesions were found in the 17 cervical stumps.

7. Four per cent of the excised uteri were the seat of endometrial hyperplasia, and endometrial polyps were found in 14 per cent.

8. The surface area of the excised vaginal integument was measured in 27 cases and averaged approximately 100 square centimeters.

9. There were no known recurrences of procidentia in this series, although the follow-up period is inadequate.

CONCLUSIONS

1. Massive genital prolapse is cured by the total obliteration of the vagina.

2. A panhysterocolpectomy, or total vaginectomy if the uterus was previously removed, can be carried out without exposing even the aged patient to a prohibitive operative risk.

3. Vaginal obliteration should be performed only on individuals who are willing to forego the use of the vagina for sexual intercourse.

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INTRACRANIAL PRESSURE AND ACCELERATION ACCOMPANYING HEAD IMPACTS IN HUMAN CADAVERS

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IN THE COURSE of an investigation undertaken to determine the effect of head impact into laminated and tempered safety glass of the type commonly used in doors and side windows of automobiles, the acceleration of the head and intracranial pressures and their time durations were measured. The relationship between pressure, acceleration, and the impact velocity was determined, and the motions of the head as it penetrated the glass were studied with the aid of cinephotography.

TEST PROCEDURE

Previous experiments indicated the desirability of using intact cadavers in tests of this type. The range of impact velocities was provided by an aluminum carriage mounted on two vertical rails in an unused elevator shaft. The carriage consisted of a very light aluminum frame and web belts which supported the body of the cadaver tilted at an angle of 30 degrees with the horizontal with the head down (Fig. 1). An automobile door containing the glass to be used in the test was mounted solidly below the carriage. The cadaver was securely strapped in place on the carriage face down with the head positioned to strike the center of the glass panel.

To conduct a test the body and carriage were raised to the height necessary to produce the desired impact velocity by means of a cable operated by an electric winch. The actual impact velocity was determined by the interruption of two electric circuits just before impact occurred. The carriage was released with the use of a quick release mechanism, and it fell down the shaft guided by the rails. Since the head was lower than the rest of the body, it struck the glass before any portion of the body contacted the frame of the door or any other structure. After the impact of the head against the glass was complete, the torso was brought to rest and its energy absorbed by a large block of styrofoam.

Since the cranial cavity of the cadaver is not completely filled with brain and fluid, it was necessary to provide a special preparation of the head to obtain a significant pressure indication. This was performed by replacing the brain with gelatin having a specific gravity of 1.05. The right temporal and left parietal regions were exposed through circular scalp incisions of about 1½ inches in diameter. Holes about ¼ inch in diameter were drilled through the bone in these areas and were tapped to receive pressure gauges. A rectangular section of scalp was removed from the midoccipital area to permit the mounting of an accelerometer in contact with the bone. Two studs were cemented to the skull with epoxy resin cement to hold the accelerometer in place on the skull in one series of tests whereas in another series the accelerometer was held in place by means of a strap passed around the head.

Most of the brain tissue was removed by applying suction to a flexible copper tube inserted into the cranial cavity through the drilled holes. The removal of the brain was

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This research was supported by a grant from the Ford Motor Company.

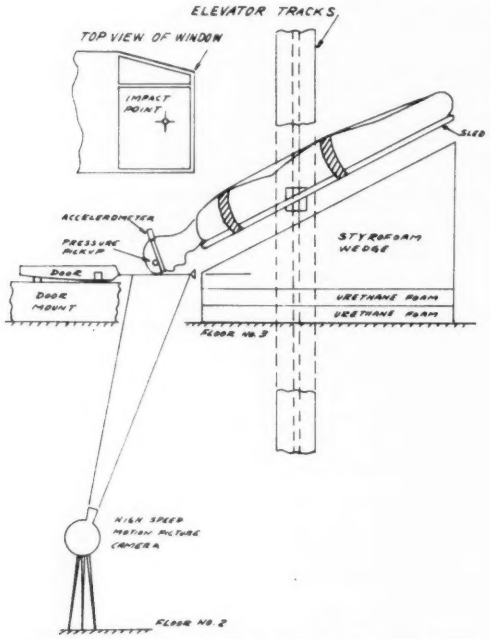

FIG. 1. Impact test setup at point of head impact with car door window.

facilitated by running water into the hole on one side, while applying suction to the other side. Special care was taken to lacerate and tear the dural membrane forming the falx cerebri and the tentorium cerebelli to insure that no air would be trapped when the head was filled with gelatin. After filling the cranial cavity, corks were used to plug the holes temporarily and the head was packed in ice to facilitate setting of the gelatin. Just before testing the corks were removed, a little liquid gelatin was added to bring the level to the surface of the bone, and pressure gauges were screwed into place.

Ninety-five tests were conducted using 10 cadavers. In 6 of the cadavers the legs were amputated at the knee to provide the necessary clearance in the testing apparatus while in the remaining 4 cadavers, the legs were doubled back and tied down. In one series of tests the pressures were measured with 300 pounds per square inch (p.s.i.) capacity pressure gauges. In another series of tests the gauges used were specially designed and consisted of a clamped edge diaphragm containing a strain gauge whose output was directly proportional to the pressure applied to the gauge. The gauges were calibrated by means of a dead weight gauge tester and were checked for response to acceleration before being used.

Two kinds and two sizes of safety glass were used in this investigation. One of the types of glass was laminated safety glass which consists of two panes of annealed glass bonded together with a plastic interlayer. The other type of glass was tempered safety glass which consists of a single sheet of glass with air-quenched surfaces. When the panes of laminated glass are broken the plastic interlayer tends to hold the glass fragments together. When tempered glass fractures at any point, it separates into granular fragments which are relatively smooth edged. In the first series of tests, ¼ inch thick laminated glass with a 15 mil plastic interlayer, and 7/32 inch thick tempered glass panels approximately 15 by 20 inches were used. In the second series, the tempered glass thickness was changed to 3/16 inch which was more representative of current and future automobile production trends and the panel size was approximately 16 by 28 inches. High speed motion picture cameras obtained front and bottom views of the impact. In some of the tests, a third camera was used to obtain a side view. Camera speeds were varied from 1,000 to 3,000 frames per second. For some tests a crystal accelerometer was mounted on the glass at

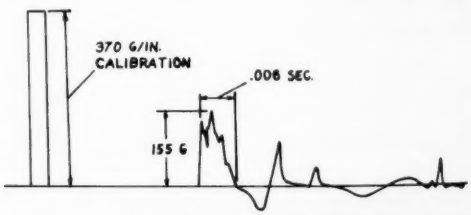

FIG. 2. Acceleration produced by impact to tempered glass panel 15 by 20 by 7/32 inch at 13.7 miles per hour measured on posterior of skull. Glass not broken.

the point of the blow on the side opposite the point of impact.

RESULTS

The heads were permitted to strike the glass with impact velocities varying from 2.5 to 34.8 miles per hour. The laminated glass generally broke at impact velocities of 3.9 to 5.8 miles per hour, but in some cases the laminated glass did not break at an impact velocity of 5.8 miles per hour. The tempered glass panels 15 by 20 by 7/32 inch thick broke at an impact velocity of 13.3 miles per hour, but 1 remained unbroken at an impact velocity of 15.1 miles per hour. The tempered glass panels 16 by 28 by 3/16 inch thick broke at impact velocities of 11.2 miles per hour, but some failed to break at velocities as high as 13.7 miles per hour.

The acceleration measured on the glass was from 4 to 6 times as great as the acceleration measured on the back of the head. This difference is due to the deformation of the scalp at the point of contact with the glass and the deformation of the skull itself due to the impact. At the higher impact velocities several peaks of acceleration occurred immediately after the blow. These peaks are probably a function of the mounting of the glass in the door frame, the elasticity of the skull, and the elastic or plastic behavior of the door itself and its mounting. These events probably occurred in succession giving rise to the acceleration peaks found on the records (Fig. 2). The total duration of the acceleration varied from 6 to 12 milliseconds.

Peak accelerations as high as 229 g were recorded for impacts to tempered glass with an impact velocity of 25.4 miles per hour. However, it is believed that the average acceleration is of greater significance where brain damage is concerned than is the peak value and the maximum average acceleration for tempered glass impact was about 125 g. For laminated glass impact the maximum average value was about 90 g.

Average pressures and their time duration are considered to be of primary significance

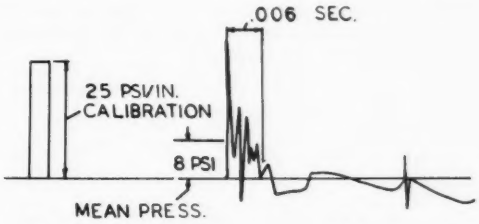

FIG. 3. Temporal pressure produced by impact to tempered glass panel 15 by 20 by 7/32 inch at 13.7 miles per hour. Glass not broken.

in concussive brain damage, and the average pressures were obtained from the tests. The pressure records indicated several peaks (Fig. 3) as did the acceleration records and probably for the same reasons. The total pressure generally lasted from 6 to 12 milliseconds. In general the intracranial pressures produced by impact to the laminated glass were lower than those obtained by impact to tempered glass. However, at speeds above the breaking range for 3/16 inch thick tempered glass, the average pressures recorded were below those obtained on laminated glass. The initial peak of the parietal pressure was frequently negative which was followed by a positive pressure. The reason for this fact is that when a blow is delivered to the forehead the parietal regions of the skull bend outward increasing the transverse dimension of the skull pulling bone containing the gauge away from the contents. As deformation continues and the acceleration effect is added, the initial pressure drop is followed by increased pressure in the parietal region. In the temporal region the pressure is positive throughout the duration of the blow.

The temporal pressures obtained at each impact velocity were averaged and the results are shown in Tables I, II, and III for tempered and laminated glass. From these tables it is evident that the average temporal pressure increases with the impact velocity, but when the glass breaks under impact, not only is the pressure reduced but its time duration is also reduced. It is also apparent from a comparison of the tables

TABLE I.—AVERAGE OF MEAN TEMPORAL PRESSURE VALUES OBTAINED FOR 15 BY 20 BY 7/32 INCH TEMPERED GLASS IMPACTS

No. of tests averaged	*Vel. of impact, m.p.h.*	*Right temporal pressure, p.s.i.*	*Pulse time, msecs.*	*Glass panels broken*	*Acceleration g*	*Acceleration Pulse time, msecs.*
4	3.9	1.7	9.1		16	9.1
4	5.5	3.1	8.5		20	7.6
4	7.8–8.3	5.0	8.1		39	9.7
4	9.7–10.8	7.8	7.1		40	7.5
2	11.4–12.3	9.4	7.2		52	8.4
3	13.1–13.7	10.1	10.3	1-B	54	9.9
2	15.1–15.7	20.9	7.0	1-B	96	7.1
2	25–25.4	10.9	6.0	2-B	121	6.8

TABLE II.—AVERAGE OF MEAN TEMPORAL PRESSURE VALUES OBTAINED FOR 16 BY 28 BY 3/16 INCH TEMPERED GLASS IMPACTS

No. of tests averaged	*Vel. of impact, m.p.h.*	*Right temporal pressure p.s.i.*	*Pulse time, msecs.*	*Glass panels broken*	*Acceleration g*	*Acceleration Pulse time, msecs.*
3	3.9	1.18	12.0		13.5	13
5	5.4–5.8	3.01	9.1		25.3	12
2	6.8	2.72	10.2		25.2	13
6	7.8–8.7	3.97	9.5		39.3	11
2	9.8	7.02	11.7		53.7	10
3	11.2–12.5	5.83	6.7	1-B	55.5	9.0
3	13.4–13.7	7.08	4.9	2-B	71.9	5.2
1	16.5	1.25	3.2	1-B	52.5	4.0
2	20.3–21.1	2.66	2.1	2-B	87.7	4.0
2	25.2–26.2	1.27	3.2	2-B	132.6	2.6
1	29.3	13.2	3.0	1-B	126	2.4
1	29.6	2.43	3.0	1-B	—	—

TABLE III.—AVERAGE OF MEAN TEMPORAL PRESSURE VALUES OBTAINED FOR ¼ INCH LAMINATED GLASS IMPACTS

No. of tests averaged	*Vel. of impact, m.p.h.*	*Right temporal pressure p.s.i.*	*Pulse time, msecs.*	*Glass panels broken*	*Acceleration g*	*Acceleration Pulse time, msecs.*
2	3.9	3.4	6.2	2	15	6.3
4	5.5–5.8	2.0	7.5	4	14	7.6
3	7.9–8.1	2.1	6.4	3	18	7.6
2	9–14.9	2.55	2.1	2	40.7	5.8
1	25	5.2	10.8	1	40	6.8
2	28.8–34.8	4.74	3.5	2	80.7	3.9

that the temporal pressures produced upon impact with the larger 3/16 inch thick panels are considerably less than those obtained with the smaller 7/32 inch thick panels. The data shown in the tables are summarized in the graphs in Figures 4 and 5. The average parietal pressure was always less than the temporal pressure.

In the first series of tests a skull fracture was obtained with a 25 mile per hour impact and another was obtained with a 13.3 miles per hour blow to tempered glass. The significance of these fractures should be discounted, however, since in one case the skull was found to be very soft and in the other case the head had been impacted repeatedly in previous tests which probably gave rise to a fatigue effect. In the second series of tests in which the thinner glass panels were used, careful roentgenograms of the heads and cervical spine were made before and after each test. In no test, with impact velocities as high as 34.8 miles per hour, were any fractures produced in the skull or cervical spine and no dislocations of the vertebrae were found.

In several tests, the head struck the glass panels placed at a 45 degree angle to the direction of the blow. The results obtained from these tests with regard to acceleration and pressure were quite similar to those obtained when the glass was normal to the direction of the blow.

DISCUSSION

Extensive tests conducted on dogs over a long period of time and previously reported (1, 2) have indicated that the primary cause of concussion is shear stress in the brain stem area immediately over the foramen magnum. This shear stress is produced whenever dynamic pressures are set up within the cranial cavity. As shown before (3), the magnitude of the shear stress is dependent on the magnitude of the pressure produced and its time duration. Pressure occurs as a result of the deformation of the skull and its acceleration following a blow. Acceleration alone is not a measure of concussive effect since the pressure produced is also a function of the skull deformation, as has been indicated previously (4). While the pressures and time durations required to produce concussion are well known for the dog, these values have no relation to those required to produce concussion in the human.

The conditions under which these tests were conducted differed from head impact in the living in that gelatin was substituted

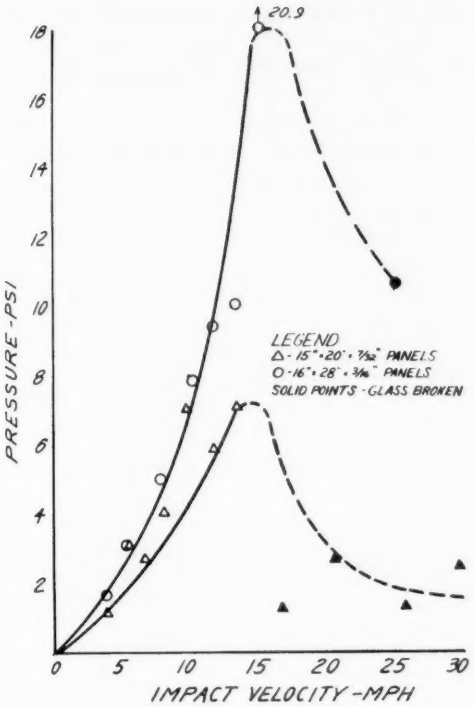

FIG. 4.

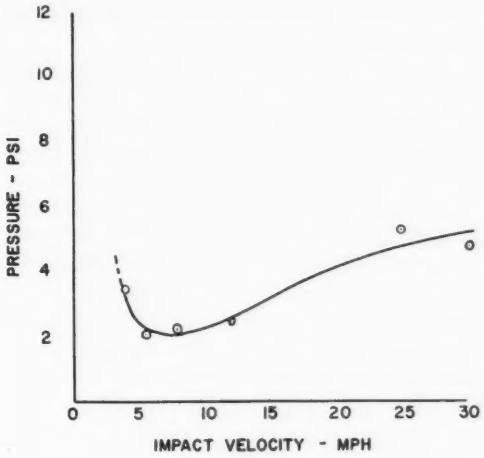

FIG. 5.

FIG. 4. Average of mean temporal pressure versus impact velocity for head impact to tempered glass.

FIG. 5. Average of mean temporal pressure versus impact velocity for head impact to ¼ inch laminated glass.

for the brain, and cerebrospinal fluid and vessels containing blood were absent from the cranial cavity and scalp. The energy absorption of the scalp of the cadaver would be somewhat different from that of living scalp, but the pressure produced by the deformation of the skull would be quite similar in the living and the dead. The acceleration produced would give rise to the same triangular pressure distribution in both cases, with the maximum at the point of impact and decreasing to zero at a point along the line of impact directly opposite the impact point. The effect of this triangular pressure distribution is observed in the fact that the temporal pressure record was always greater in magnitude than the parietal pressure. Because of this triangular pressure distribution which occurs as a result of the acceleration, and is added to the pressure produced by the deformation of the head, the magnitude of the pressure will vary from one point to another within the cranial cavity. The significant pressure, however, is that produced in the region above the foramen magnum giving rise to the shear stress in this area. The value of the pressure obtained in any other region of the head is only of significance when compared with pressures measured at the same point resulting from blows delivered to a single area. In our investigation all blows were applied to the forehead at the midline so that the comparison of pressures in the temporal region for all blows is valid.

Comparison of the temporal pressures with increasing impact velocities to tempered glass gives a very interesting and significant result. As long as the glass remains intact the temporal pressure increases with increasing impact velocity, the time duration remaining fairly constant. However, when the glass breaks, both the pressure and time duration drop abruptly

and remain fairly constant with increasing impact velocities.

Another significant fact observed in these tests was that with the thinner glass panels no fractures of the skull or vertebrae occurred, nor were any dislocations observed in the cervical spine. The study of the cinephotographs of the head at impact are instructive. When the glass panel does not break the head becomes hyperextended after the initial impact. Two other oscillations of the head follow resulting in 3 or 4 blows of the head against the panel. This reaction is undoubtedly due to the fact that the torso does not rebound from its impact position because of the absorption of energy by the styrofoam and the effect of gravity keeping it in place.

When the glass breaks, there is extreme hyperflexion of the head followed by hyperextension and 2 or 3 oscillations of the head. It is most amazing that dislocation or fracture of the cervical spine is not produced by these oscillations. A study of the cinephotographs indicates that in addition to the first blow, multiple impacts of sufficient severity occur to produce local injuries. Severe deformation of the scalp has been observed on the second impact in quite a number of these tests.

SUMMARY

1. Heads of human cadavers were permitted to strike glass panels at impact velocities of from 2.5 to 34.8 miles per hour.

2. Average accelerations as high as 125 and 90 g measured at the occiput occurred for forehead midline blows to tempered and laminated glass. The time duration varied from about 6 to 12 milliseconds.

3. Average temporal pressures reached a maximum of 20.9 p.s.i. with the glass remaining intact and the pressures lasting from about 6 to 12 milliseconds. When the glass broke, the pressures and their time durations remained very low. Parietal pressures were always less than temporal pressures.

4. Study of the cinephotographs showed that the head oscillated 3 or 4 times after impact to the glass panel. The oscillations also occurred when the glass fractured but were reduced in number to an average of about 2½.

5. Under the conditions of these experiments, no fractures of the skull or cervical spine or dislocations of the vertebrae were noted when the thinner glass panels were used.

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TWENTY-FIVE YEARS OF EXPERIENCE WITH ELECTIVE GASTRIC RESECTION FOR GASTRIC ULCER

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A TOTAL of 1,936 patients underwent elective gastric resections for peptic ulcer at the Presbyterian Hospital in New York during the years from 1936 to 1957 inclusive. This figure does not include the emergency resections performed for acute massive hemorrhage, and for acute perforations, nor the resections accompanied by a take-down of a previously made gastrojejunostomy.

Of the elective cases, 1,488 were classified as duodenal ulcers and have been reported previously (1). The present article pertains to the 448 patients who were classified as having gastric ulcers. The division of the patients into the two groups is useful but not wholly justified. In the pathologic reports of the duodenal ulcers, 158 patients, 10.7 per cent, were noted to have ulceration of the gastric mucosa also, sometimes continuously with the duodenal ulcer, i.e., pyloric in location, sometimes separately, and sometimes represented only by a scar. The ulcers can occur in the duodenum and stomach at different times or concomitantly. Similarly, approximately 10 per cent of the ulcers classified pathologically as gastric seemed at roentgenographic examination or at operation to have a duodenal component. Because the pathologic report did not mention duodenal ulceration, these were classified with the gastric ulcers.

The patients who comprised the two groups differed from each other in several respects. In the gastric group, men outnumbered women 2 to 1; in the duodenal, 4 to 1. The stated ages of the patients at the time of resection are given in Table I. The patients with duodenal ulcers were younger. Eighty-one per cent of them were in the fourth, fifth, and sixth decades, whereas 82 per cent of the patients with gastric ulcer were in the fifth, sixth, and seventh decades. Fifty-seven per cent of the duodenal ulcer patients were 50 years of age or younger, contrasted with 38 per cent of patients with gastric ulcers. During the years 1936 to 1957, the proportion of gastric ulcer patients who at operation were lighter than 20 per cent below average for their height, age, and sex varied from 1 in 3 to 1 in 4; for the duodenal ulcer patients the proportion varied from 1 in 5 to 1 in 7. Both groups were better nourished when operated on toward the end of the period than they were in the early years. There was an urgency to operate on the patients with gastric ulcers because of the ever-present fear that the lesion was malignant, and the extent of the resection was often greater than would be necessary if the surgeon had been certain that the ulcer was benign. Because of the differences between the patients in the two groups, their courses after resection must be compared with caution.

DIFFERENTIAL DIAGNOSIS

The gastric ulcers considered in this report comprise only those that proved to be benign. The difficulty of differential diagnosis between benign and malignant gastric ulcers has been discussed by Hennig and Harvey. Individual considerations dominate the management of each patient who presents himself with an ulcerating gastric lesion, especially the matter of how strongly the sum of evidence in his case suggests that the ulcer is malignant. The mere fact that an ulcer is demonstrated makes cancer a pos-

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This study was carried out with the aid of the Dr. F. B. St. John Special Fund.

TABLE I.—AGES OF PATIENTS AT TIME OF GASTRIC RESECTION

Age, years	*Gastric ulcers* *Per cent*	*Duodenal ulcers* *Per cent*
30 or less	4	5
31 to 40	10	20
41 to 50	24	32
51 to 60	36	29
61 to 70	22	12
71 and over	4	2

TABLE II.—FOLLOW-UP STATUS OF 436 PATIENTS WHO SURVIVED PARTIAL GASTRECTOMY FOR GASTRIC ULCER

	Years of operation		
	follow-up period, years		
	1936 to 1945 *15 to 25*	*1946 to 1950* *10 to 14*	*1951 to 1957* *3 to 9*
No. of patients	80	133	223
Late deaths, per cent	50	33	13
Still being followed up in 1959, 1960, per cent	45	61	84
Lost to follow-up, per cent*	5	6	2

*After an average follow-up period of 6 years.

sibility. New methods of differential diagnosis are proposed from time to time, but the chief test is still the roentgenologic study. The clinician must evaluate its significance in each patient. The roentgenologist's report in 36 per cent of the benign gastric ulcers especially warned with more or less emphasis that the ulcer might be malignant and in another 5 per cent stated that such marked obstruction was present that no attempt at differential diagnosis was possible. The personnel of the roentgenologic staff has changed over the years, which may partly account for the fact that specific warnings of this kind appear in 25 per cent of the reports in recent years instead of 40 per cent as formerly.

If, when all evidence is reviewed, the ulcer appears to be probably benign, it may be treated as such for 2 or 3 weeks. If there is little healing in that time it is usually best to resect, but if, by roentgenographic study, the ulcer is clearly seen to be healing, conservative management may be continued until the period of treatment has reached 6 or 8 weeks. If the lesion is not healed by then, operation should usually be recommended; if it appears to be healed, confirmatory roentgenographic studies are made at 6 months and a year later to see whether it remains healed. It is among the ulcerating lesions whose nature is hard to determine without operation that the carcinomas with the highest 5 year arrest rate are found —32 per cent in Hennig's and Harvey's series.

RESULTS AFTER OPERATION

Follow-up record. Of the 448 patients, 12 died in hospital after operation, leaving 436 to be followed up. Of these, by 1 January 1961, 26 per cent had died after leaving the hospital, 70 per cent were being actively followed up, 4 per cent had been lost after an average follow-up period of 6 years. Table II illustrates the length of time of the follow-up period. Thirty-six patients still living have been followed up for 15 to 25 years, and another 81 patients for 10 to 14 years.

Deaths in hospital. Of the 12 (2.9 per cent) deaths in the hospital, 7 occurred before 1946. In the past 15 years the postoperative death rate after elective resections for gastric ulcer has been 1.4 per cent. The chief causes of the deaths were cardiovascular or pulmonary in nature in all but 3 instances, in contrast to the deaths following resections for duodenal ulcer, most of which were related to surgical difficulties in the duodenopancreatic area.

Late deaths. The late deaths, i.e., those that occurred after the patient left the hospital, number 26 per cent of the patients, compared with 13 per cent for the patients with duodenal ulcer who were a younger group. Table III shows the ascribed causes of the late deaths. Two patients whose resections were performed prior to 1945 died of late operative complications. One other died with acute renal failure 6 months after the operation, and 1 died in 4 months in a state of malnutrition of unknown origin that existed before his operation. None of the other deaths apparently could have resulted from peptic ulcer, the operation, or the anesthesia. About 30 per cent of the

patients who died reached their eighth or ninth decades, as have nearly 20 per cent of the patients who are still living.

Incidence of gastric carcinoma. In nearly 1 per cent of the patients with gastric ulcer carcinoma has already developed in the remaining segment of the stomach, proportionately 5 times as many as occurred among the younger duodenal ulcer group.

Marginal ulcers. In 7 patients—1.5 per cent—evidence of recurrent ulcers has developed, compared with about 8 per cent for patients who underwent resection without vagectomy for duodenal ulcer. None of the 7 patients underwent vagectomy at any time, and only 1 a secondary operation for the recurrent ulcer. His was the only recurrent benign ulcer lying wholly within the stomach that has been demonstrated in the Presbyterian Hospital after partial gastrectomy for any peptic ulcer. The ulcer was thought to be malignant and chiefly for that reason was resected, together with a small jejunal ulcer. This patient and 1 other among the 7 patients had unconfirmed evidence of a duodenal ulcer as well as the gastric ulcer before the original resection. Three of the 7 patients had severe arthritis, and the original and recurrent ulcers developed in relation to steroid therapy. Bleeding in 2 patients followed heavy indulgence in alcohol, and 1 patient had pain but no other evidence of ulcer following an illness and loss of his job. These 7 recurrent ulcers differed from those that followed resections for duodenal ulcer in that all but 1 had an obvious inciting cause, over half of them appeared 8 years or more after resection—after duodenal ulcers, recurrences nearly all appeared earlier—and as a group they yielded readily to conservative therapy.

Return to work. Eighty-eight per cent of the patients are known to have returned to work or usual activity, 6 per cent did not, and for 6 per cent the record in this respect is incomplete. The failures to return to work were chiefly for reasons unrelated to the operation, such as a serious concomitant illness.

TABLE III.—ASCRIBED CAUSES OF DEATHS AFTER PATIENT LEFT HOSPITAL

Cause of death	*No. of patients*
Acute heart failure	32
Chronic heart failure	11
Thromboses, emboli, and strokes	12
General arteriosclerosis, aneurysm, hypertension, total	7
Renal failure	6
Cirrhosis of liver	9
Carcinoma, not of stomach	14
Carcinoma of stomach	2
Late operative complications	2
Pneumonia, accidents, unknown, each 3, total	9
Miscellaneous, not more than 2 alike, total	11
Total	115

TABLE IV.—LENGTH OF SPECIMENS MEASURED ALONG GREATER CURVATURE COMPARED WITH POSTOPERATIVE NUTRITIONAL STATUS

	Years of operation		
	1936 to 1948	*1949 to 1953*	*1954 to 1957*
	Per cent	*Per cent*	*Per cent*
Length of specimens, cm.			
0–18	41	32	47
19–23	41	40	34
24 Plus	17	27	16
Unknown	1	1	3
Patients who gained weight	71	57	63
Patients heavier than 20 per cent below average	80	74	78

Size of resection. The report of the patients whose resections were performed for duodenal ulcers (1) shows that an increase in the amount of stomach removed, within the range of 50 to 75 per cent, had little effect on the incidence of recurrent ulcers but adversely affected both the patient's ability to maintain weight after operation and the incidence of symptoms of dumping. The resections performed for gastric ulcers do not lend themselves well to a similar study because the size of the resected specimens differed little over the years. Relatively large specimens of stomach were often removed in all years when the ulcer lay in the proximal part of the stomach, whenever the surgeon feared that the ulcer was malignant, and when the stomach was dilated secondary to pyloric obstruction. Nevertheless, Table IV shows a drop in the number of more limited resections in the years 1949 to 1953 and a reverse in this

TABLE V.—INCIDENCE AND SEVERITY OF DUMPING AS OF 1959 TO 1960

	Years of operation		
	1936 to 1948	*1949 to 1953*	*1954 to 1957*
No. of patients	149	175	112
Patients with records concerning dumping	131	160	107
Mild dumping, per cent*	14	20	24
Moderately severe dumping, per cent†	0	4	6
Severe dumping, per cent‡	0	3	2

*Dumping occasionally, usually avoidable.
†Dumping usually avoidable, but only by taking special precautions every day.
‡Dumping daily in spite of taking precautions.
Percentages are based on the number of patients with records concerning dumping.

TABLE VI.—WEIGHT OF PATIENTS IN RELATION TO TABLE OF AVERAGE WEIGHTS

Weight of patients	*Before operation* *Per cent*	*After operation* *Per cent*
25 per cent below average	15	11
20–25 per cent below average	9	7
1–20 per cent below average	35	40
Average or over	19	19
Unknown*	22	23

Average weights are taken from a table supplied by The Equitable Life Assurance Society of America that gives average weights for sex, age, and height through age 45. In the above table, age 45 is used for older patients. Master, Lasser, and Beckman's tables indicate that average weights fall after 65 years of age.
*If the patients operated on previous to 1946 are not counted, the per cent of unknowns drops to 15, without other significant changes in the table.

trend beginning in 1954. A substantial number of patients experience a gain in weight beginning about 5 years after operation, and the patients operated on after 1954 have not yet had time to benefit by this. Difficulties in maintaining weight after operation increased when the more extensive resections were most often performed, and decreased as they were abandoned. This observation is similar to that regarding the resections for duodenal ulcer.

There is hardly ever need for resecting more than 40 or 50 per cent of the stomach for a benign gastric ulcer. The rule of procedure in operating on gastric ulcers may be stated as follows. When the stomach is exposed if the surgeon still cannot tell with reasonable certainty whether the lesion is malignant or benign, and if his surgical procedure would be substantially more radical if the ulcer were malignant, then the stomach should be opened and adequate biopsy specimens taken of the ulcer edge and base to prove the diagnosis by quick frozen section. Often biopsies of small ulcers of the distal portion of the stomach are unnecessary, but in the proximal half of the stomach many lesions that would require high resections or even a total gastrectomy if malignant can be cured by a 50 per cent or less resection if benign. If an ulcer in the proximal half of the stomach is proved to be benign if may be left unless actively bleeding, or, better, when the resection is done, it may be excised separately by cutting along the very edge of the ulcer and closing the defect in the gastric wall. Biopsies properly performed afford the most accurate means available of establishing the correct diagnosis and avoiding performance of the wrong operation for the lesion at hand, an error that may be fatal or crippling to the patient. Only with the help of the pathologist can the differential diagnosis of gastric lesions approach the accuracy that has been achieved in operations on the breast.

Dumping. The number of patients who admitted to having symptoms of dumping as of 1959 to 1960—or had them prior to their death if they were no longer alive in 1959—is given in Table V. The incidence is similar to that of the duodenal ulcer patients. Four of the 7 patients considered to have severe symptoms had overt psychologic problems, and over half of those with moderately severe symptoms were similarly affected or were specifically noted to be "tense," "a worrier," or "neurotic" before operation. The next most common circumstance among the severe dumpers was an unusually high resection. In most instances, symptoms of dumping diminished or disappeared with time, but this fact does not fully explain the good record of the patients whose resections were performed prior to 1949. Polya anastomoses with their big stomas were commonly employed in those years. Later, Hofmeister or Billroth I types were nearly always performed. Except among the psychologically unstable patients, dumping was infrequently more than an avoidable nuisance

but, when severe, could cause a major disability.

Nutrition. The state of the nutrition of the patients is indicated in Table VI which shows how little the weights of the patients as a group changed postoperatively. The large number of "unknowns" consists almost entirely of patients who died without record of their height. The same proportion of these patients gained weight after operation as in the whole group, and their nutritional record was probably similar. Average weight and desirable weight are not synonymous. A table of desirable weights, "i.e., weights associated with lowest mortality," has been published by the Metropolitan Life Insurance Company. According to their table, weights even 20 to 25 per cent below their average weights, notably among older women of small frame, may be within the desirable range. Within limits, leanness in a patient is not in itself an important cause for dissatisfaction with the results of a gastrectomy.

Sixty-three per cent of the patients experienced a gain over what they weighed shortly before operation, 32 per cent a loss, and for 5 per cent no record is available. Twelve of the 63 per cent who at 5 years showed a gain ultimately lost, most of them when they reached or approached 70 years of age. Of those who began to lose weight soon after operation, 25 of the 32 per cent had one or more of the following extenuating circumstances: they remained within the desirable weight range for their height; they had a severe concomitant illness other than the ulcer; a few were over 70 years of age when operated on; a small number had resections estimated at over 80 per cent of the stomach. Seven per cent lost weight for no apparent reason except a resection of not over 75 per cent.

Seventeen patients who were heavier than 20 per cent below average before operation became and remained lighter than this limit after operation. Six of these had severe illnesses other than ulcer, 5 underwent unusually high resections, 6 have no obvious reason for their loss except a moderate-sized resection. Four of the last 6 underwent Billroth I procedures. Twenty-six patients who were lighter than 20 per cent below average before operation lost weight after operation. Of these, 13 had serious illnesses other than ulcer, 6 had high resections, 1 died at the age of 82 years, 8 years after resection. Six had no explanation for their weight loss other than a moderate-sized resection. Twelve patients, therefore, less than 3 per cent of all operated on, comprise the group who are most suspect of having been harmed nutritionally by the operation. Only 3 of the 12 patients have complaints that seem to be based on their low weight.

TABLE VII.—POSTOPERATIVE COURSE NOT THOROUGHLY SATISFACTORY

	No. of patients	*No. excused**	*Not fully satisfactory*	
			No.	*Per cent*
Recurrent ulcer	7	0	7	1.6
Late severe surgical complications	2	0	2	0.5
Severe dumping	7	0	7	1.6
Moderately severe dumping	12	0	12	2.7
Possibly harmful weight loss with symptoms†	10	3	7	1.6
Possibly harmful weight loss without symptoms	31	17	14	3.2
Gained, but still low in weight, with symptoms	9	2	7	1.6
Gained, but still low in weight, without symptoms	13	5	8	1.8
Lost 10 per cent of preoperative weight but still satisfactory weight, with symptoms	13	5	8	1.8
Lost 10 per cent of preoperative weight but still satisfactory weight, without symptoms	33	21	12	2.7
Active pulmonary tuberculosis (3 years after operation)	1	0	1	.2

*Patients whose difficulties, other than the ulcer or operation, could account for the unsatisfactory element in their course after operation. The difficulty was nearly always an illness.

†The symptoms referred to are usually inability to eat a big meal or occasional dumping.

Clinical evaluation. There is no standard table of desirable weights from the point of view of the surgeon who must be concerned not only with his patients' longevity but also with their ability to enjoy an active, happy life. The result after operation can nearly always be called satisfactory if the patient has never shown evidence of a re-

current ulcer, persistent severe dumping, or inability to maintain a weight that is better than 25 per cent below average. Two less frequent causes for dissatisfaction are serious late operative complications and active pulmonary tuberculosis that is manifest soon after operation. Table VII lists 11 categories of causes for possible dissatisfaction with the result of the operation. The decision of whether or not to assign patients to these groups can be made with a fair degree of objectivity. The result in nearly all of these patients is unsatisfactory only in the sense that one could wish for some further improvement. All but a very few are better than they were before operation. If one may postulate that the operation is not expected to alter a lean habitus or a neurotic temperament but to cure an ulcer without inflicting serious harm, then resection for gastric ulcer, properly performed, has been successful in over 95 per cent of the patients.

CONCLUSIONS

The record of patients who had gastric resections for a benign gastric ulcer is better in nearly all respects than the record of their counterparts who had duodenal ulcers. The problem of whether the ulcer is benign or malignant dominates the management of the patient with gastric ulcer before operation. The postoperative death rate is slightly higher for the gastric ulcer patients and the late death rate distinctly higher, probably because the gastric ulcer patients as a group were older. Recurrent ulcers were unusual among the gastric ulcer patients and healed without a second operation except in 1 bizarre instance. The incidence of low weight and dumping after operation depended chiefly on the habitus and psychologic stability of the patient. Both were most frequent when resections of more than 50 per cent were performed. Resections of more than 50 per cent are rarely necessary for benign gastric ulcer, and vagectomies are not needed unless there is ulceration of the duodenum as well as of the stomach. No type of anastomosis used has been clearly the best. The Polya-Balfour modification of the Billroth II anastomosis, with its large stoma, has at least as good a record as the others.

SUMMARY

1. The record is given of 448 patients with resections for benign gastric ulcers performed between 1936 and 1957, with a follow-up study ranging from 3 to 25 years.

2. Four per cent of the patients were lost after an average follow-up period of 6 years. Ninety-six per cent were being currently followed up in 1959 and 1960 or have died.

3. The hospital death rate after operation for the past 15 years has been 1.4 per cent.

4. The group of patients who had gastric ulcers have fared better than the group who had duodenal ulcers in nearly every category, in spite of the greater age of the former. The late development of gastric carcinoma is an exception in this record.

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INVESTIGATIONS REGARDING THE MANAGEMENT OF THE DUODENAL STUMP

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AFTER GASTRIC RESECTION, management of the duodenal stump presents no problem in the great majority of cases. In certain instances in which advanced ulcerative disease of the duodenum is known to exist, the difficult stump may be avoided by utilization of an alternative procedure such as vagotomy and gastroenterostomy or the Finsterer exclusion operation. In spite of these possibilities, the gastric surgeon is, on occasions, faced with the problem of duodenal stump management in cases in which ordinary methods of closure promise little success. The greatest single factor in the mortality and morbidity resulting from gastric resection today relates to the complications of inadequate duodenal closure, according to Hardy.

The following studies were carried out in order to observe the reaction to some established techniques as well as to a number of unestablished procedures for duodenal stump management.

MATERIALS AND METHODS

Unselected adult mongrel dogs were used for all experiments. During the operative procedures anesthesia was maintained by fractional intravenous injections of pentobarbital. By utilizing sterile technique the abdomen was opened in the midline. Approximately 70 per cent of the stomach was resected, after which gastrointestinal continuity was established according to the Polya technique. A 2 layered gastrojejunostomy was constructed using intestinal No. 00 chromic catgut.

Group 1. Normal stump, 8 dogs. The purpose of these experiments was to determine the resistance of the normal duodenal stump to leakage while subjected to stress. The duodenal stump was closed with 2 layers of intestinal No. 00 chromic catgut. The first layer was continuous and the second was interrupted (Fig. 1). The abdomen was closed and the animals were confined to their cages for 1 week. At this time the abdomen was again opened, and an umbilical tape was tied around the afferent loop of jejunum near the ligament of Treitz (Fig. 2). The closed loop of bowel continued to receive biliary and pancreatic secretions which progressively increased the intraluminal pressure with resulting stress to the duodenal stump. The length of life of each animal after afferent loop occlusion was recorded. A postmortem examination was carried out to determine which leaked first, the duodenal stump or the normal duodenal wall.

Group 2. Open stump, 8 dogs. The duodenal stump was not closed nor was the abdomen drained. An umbilical tape tie was placed around the afferent loop of jejunum. Survival time was recorded for all animals.

Group 3. Two layer closure of the difficult stump, 8 dogs. These studies as well as those to be described were carried out upon animals with "difficult" duodenal stumps. The abdomen was opened and the upper duodenum was dissected free. A full thickness defect of the posterior duodenal wall measuring 1 centimeter in diameter was created. The head of the pancreas was then sutured into the defect (Fig. 3). This preparation was designed to simulate posterior perforation of an ulcer into the head of the pancreas. One week later a gastric resection was carried out and the duodenal stump was closed as described for group 1. After the lapse of

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Aided by U. S. Public Health Service, Grant A-4644.

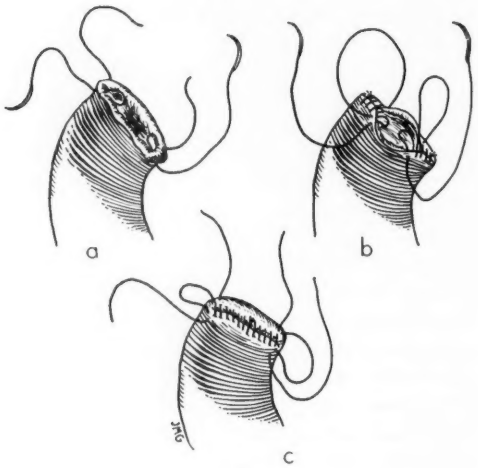

FIG. 1.

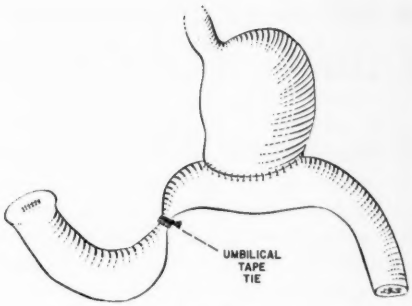

FIG. 2.

FIG. 1. Method of 2 layer duodenal stump closure.
FIG. 2. Method of occluding afferent loop.

another week, ligation of the afferent loop was effected. Survival time for each animal was recorded. It was determined at postmortem examination whether the duodenal stump or the normal duodenal wall had ruptured.

Group 4. Difficult stump closure with omentum, 8 dogs. An ulcer of the duodenum was created as previously described. One week later, gastric resection was carried out. Viable omentum was introduced into the duodenum where it was maintained with interrupted No. 00 chromic catgut sutures (Fig. 4). After the lapse of 1 week the afferent loop of the gastrojejunostomy was occluded with umbilical tape. Survival time as well as the site of duodenal leakage was recorded for each animal.

Group 5. Jejunal patch of difficult stump, 8 dogs. A perforated duodenal ulcer was prepared in 8 animals as previously described. One week later the stomach was resected. A segment of the afferent loop of jejunum with blood supply intact was removed from the continuity of the gastrointestinal tract. An end-to-end jejunojejunostomy was established. The serosa of the jejunal segment was sutured to the posterior duodenal wall with interrupted chromic catgut sutures. The needle was first passed through the scarred pancreas and then into the posterior duodenal wall (Fig. 5). It was then passed through the serosal layer of the jejunal segment. All the sutures which comprised the posterior layer were placed before any were tied. The jejunal segment was then opened along its antimesenteric border. The corners were trimmed away and hemostasis was effected. Two full length intestinal No. 00 chromic catgut sutures were then placed at the midportion of the posterior suture line. They were extended laterally to include the mucosa as well as the other layers of the duodenum and the jejunal patch. Anteriorly these sutures were continued according to the method of Connell and tied to each other. The anterior suture line was reinforced with interrupted Lembert sutures of No. 00 chromic catgut. One week later the abdominal cavity was opened so that an umbilical tape tie could be passed around the afferent jejunal loop of the gastrojejunostomy. The site of duodenal leakage was determined at the time of death, and survival time was recorded for each animal.

Group 6. A, Management of normal duodenal stump with Roux-Y segment of jejunum, 10 dogs. After gastric resection the afferent loop of jejunum was divided. The distal jejunum was then anastomosed to the duodenum.

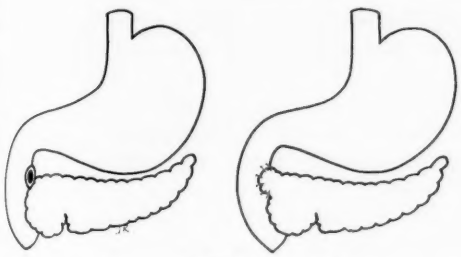

FIG. 3.

FIG. 4.

FIG. 3. a, Formation of ulcer. b, Pancreas sutured into defect after removal of full thickness of duodenal wall.

FIG. 4. Viable omentum sutured into duodenum.

FIG. 5. Jejunum patch method of duodenal closure. a, Serosal sutures. b, c, Edges of flap are trimmed to fit duodenum. d, e, Continuous trimmed posterior mucosal sutures. f, Sutures extended anteriorly according to method of Connell. g, Anterior suture line reinforced with interrupted serosal sutures.

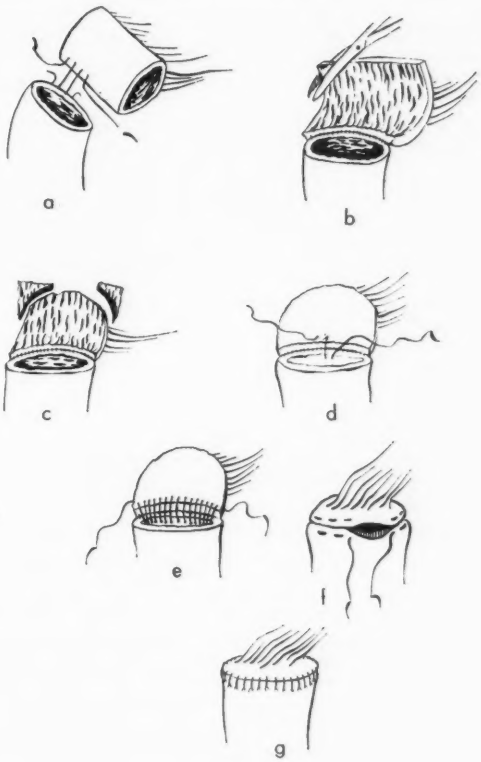

FIG. 5.

Two layers of intestinal No. 00 chromic catgut were used. The end of the proximal jejunum was then anastomosed to the side of the distal jejunum (Fig. 6). Survival time for these animals was recorded.

B, Management of difficult duodenal stump with Roux-Y segment of jejunum, 10 dogs. The experimental preparation just described would probably encourage the drainage of at least some of the alkaline duodenal secretions into the jejunal loop and consequently away from the gastroenterostomy stoma. This would be undesirable, in that it may predispose to the formation of marginal ulcers at the junction of the gastric and jejunal mucosa. A narrowed duodenojejunal stoma would encourage the duodenal contents to flow over the site of gastrointestinal anastomosis.

A full thickness defect of the duodenal wall was created in normal dogs. One week later the stomach was resected and a gastrojejunostomy was established according to the method of Polya. The efferent jejunal loop was divided and the distal portion was anastomosed to the open end of the duodenum. A posterior layer of interrupted No. 00 chromic catgut sutures was placed between the jejunum and the duodenum (Fig. 7). The needle was first placed through the serosa of the jejunum. It was then passed through the edge of the scarred pancreas and into the posterior wall of the duodenum. These sutures were tied only after all had been placed. Two chromic catgut sutures were then placed through the mucosa of the jejunum and the duodenum in the midportion of the posterior wall. They were tied

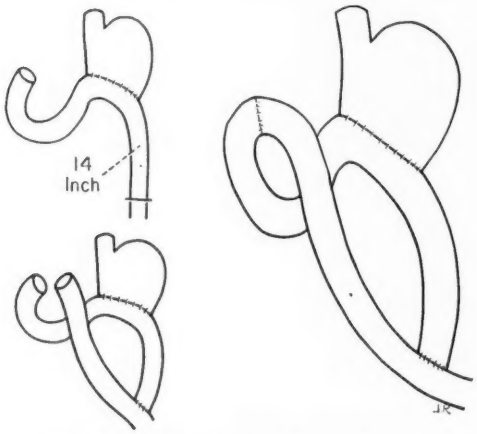

FIG. 6. Management of normal duodenal stump with Roux-Y limb of jejunum. All animals recovered.

together and then extended laterally as a continuous lock suture. A small incision was made in the anterior surface of the jejunum, after which a No. 16 French catheter was introduced into the lumen of the jejunum and threaded across the anastomosis into the duodenum. The continuous sutures were then passed to the serosal surface and continued on each side according to the method described by Connell. The suture line was reinforced anteriorally with interrupted Lembert sutures of No. 00 chromic catgut. The anterior duodenojejunal wall was further enfolded by 2 additional layers of similar sutures. The catheter was removed and the jejunostomy was closed in 2 layers. These animals were followed up and sacrificed at varying intervals.

C, Afferent limb occlusion, 6 dogs. These animals were operated upon according to the technique described for group 6B. One week later the abdomen was reopened, at which time an umbilical tape tie was placed around the afferent loop of jejunum (Fig. 8). Survival time was recorded for each animal.

D, Resistance to marginal ulceration, 5 dogs. The procedure described for group 6B was carried out. One week later, daily injections of histamine in beeswax were started. This was continued for 35 consecutive days except Sundays. The animals were then sacrificed and examined for marginal ulceration.

RESULTS

Group 1. The mean survival time for these animals was 88 hours with a range of 31 to 144 hours. In no instance had the duodenal stump leaked. Death had resulted from rupture of the descending duodenum in all animals. The peritoneal cavity was found to contain from 150 to 300 cubic centimeters of dark fluid.

Group 2. These animals exhibited a mean survival time of 19 hours. The range was from 15 to 24 hours. The peritoneal cavity of all animals was found to contain thin brown fluid.

Group 3. With this preparation the survival time ranged from 26 to 96 hours and the mean value was 46 hours. In all animals except 1 the duodenal stump leaked before the duodenal wall exhibited necrosis and perforation. The peritoneal fluid which was characteristic of duodenal perforation was found in all instances.

Group 4. Three of these animals failed to live for 1 week, at which time the afferent loop was occluded in the survivors. The mean survival time for the remaining animals was 22 hours with a range of 12 to 30 hours. In all animals the duodenal stump leaked before there was perforation of the duodenal wall.

Group 5. The mean survival time was 59 hours with a range from 18 to 108 hours. In only 3 of these dogs did the duodenal stump leak before there was perforation of the duodenal wall. The remaining animals exhibited an intact duodenal closure with perforation of the duodenal wall in the second portion.

Group 6A. The dogs of this group recovered from operation satisfactorily and presented no untoward symptoms. All animals survived the 1 week period during which they were observed. Autopsied animals revealed a healing anastomosis without evidence of leakage. The stoma was patent in all instances.

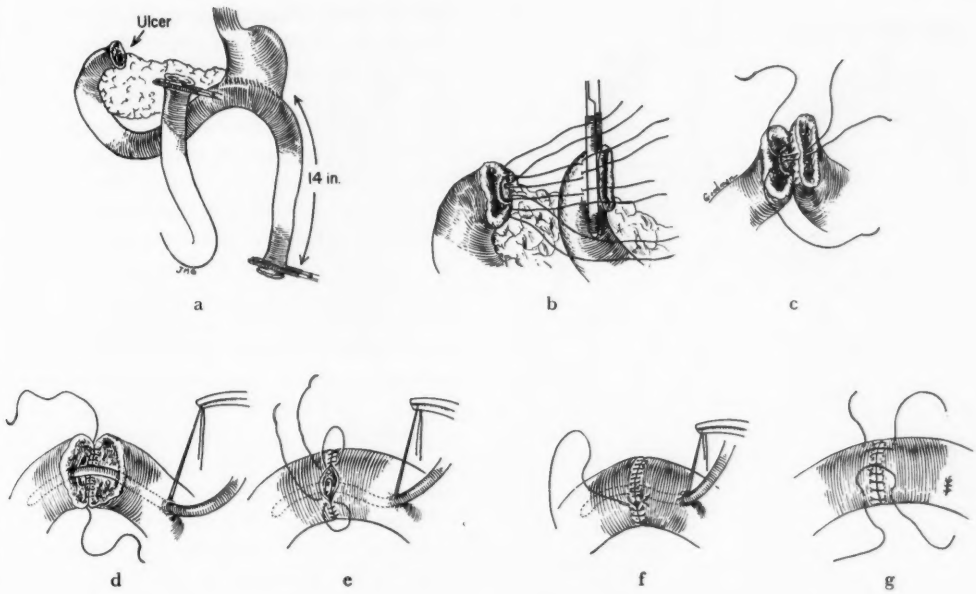

FIG. 7. Use of jejunum for difficult duodenal stump management. a, Efferent loop divided. b, No. 000 cotton sutures placed between serosa of jejunum and duodenum. In midportion, sutures pass through ulcer bed. c, Continuous No. 00 chromic sutures started in midportion posteriorly. d, Posterior continuous lock sutures completed; No. 16 French catheter threaded through stoma. e, Chromic catgut sutures continued anteriorly according to method of Connell. f, Suture line reinforced by interrupted No. 000 cotton sutures. g, Anterior walls of duodenum and jejunum further enfolded by additional rows of interrupted sutures.

Group 6B. Only 1 animal died during the period of observation and unfortunately postmortem examination was not carried out. The remaining dogs were sacrificed at intervals from 6 to 58 days. The anastomosis was well healed in all animals. Animals examined after 1 month or longer revealed duodenojejunal stomas of extremely narrow proportions. It is doubtful that any duodenal content flowed through this narrow lumen in the older animals.

Group 6C. These animals were observed for 10 days after occlusion of the afferent jejunal limb, at which time all were alive and well. This fact suggested the availability of a competent route for effective duodenal decompression with this preparation, at least during the immediate period after the operative procedure. Of particular interest was the fact that none of the anastomoses leaked, in spite of the necessity for the total volume of biliary and pancreatic secretions to travel this route in order to escape from the duodenum.

Group 6D. Four of the animals of this group revealed no evidence of gastrojejunal ulceration. One animal revealed a jejunal ulcer opposite the gastric anastomosis. Further examination revealed kinking of the afferent gastrojejunostomy limb in this animal with shunting of all duodenal content into the Roux-Y limb of jejunum. This dog, of course, would have died if the duodenal stump had not been drained into the jejunum.

DISCUSSION

Occlusion of the afferent jejunal limb following Billroth II types of gastric resection is a complication feared by all gastric sur-

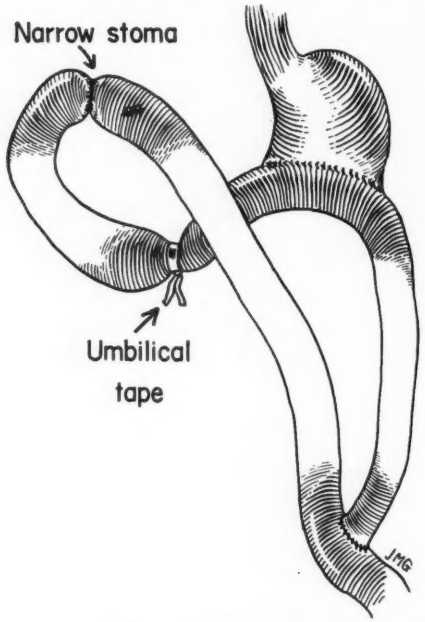

FIG. 8. Method of afferent loop occlusion used to evaluate security of duodenojejunal anastomosis.

geons. The continued drainage of biliary and pancreatic secretions into this closed intestinal segment results in increasing degrees of intraluminal pressure with mounting stress upon the closed duodenal stump. This situation eventually results in rupture of the duodenal stump or perforation of the normal duodenal wall. It occurred to us that deliberate occlusion of the afferent jejunal loop after gastric resection would constitute a suitable test for the efficacy of various methods of stump closure. Certainly a method of stump management which would resist perforation longer than the normal duodenal wall could be labeled as acceptable under most circumstances.

The results of the experiments which comprise this study clearly indicate that a 2 layer closure of the normal duodenal stump resists leakage most effectively. Utilization of the same method of closure for the difficult stump yielded less satisfactory results (Fig. 9). Several factors were responsible for the lack of security of stump closure under these circumstances. The inflamed, edematous duodenum contributed to poor healing with a greater tendency for suture line disruption under the stress of afferent loop occlusion. The sutures were also tied under considerably more than the optimal degree of tension as a result of the resistance of the rigid duodenal wall to inversion.

When a jejunal patch was used, the necessity for inversion was virtually eliminated. Consequently the sutures were under less tension and this fact probably accounts for the improved results which were obtained in this group of animals. Duodenal stump closure with viable omentum gave results scarcely better than those obtained in animals in which no attempt at duodenal closure was made (Fig. 10).

External catheter drainage of the difficult stump has been advocated by Welch and Rodkey for patients in whom satisfactory closure could not be effected in the usual manner. This method of management has certainly been utilized to good advantage when other procedures gave little promise of success. However, those who employ deliberate external duodenal fistula formation of necessity accept increased morbidity for these patients. Complications of external drainage include leakage around the catheter with peritonitis, fluid and electrolyte problems, hemorrhage, and persistent duodenocutaneous fistula, according to Caldwell and associates.

The possibility that some of the undesirable sequelae of external duodenal stump drainage might be eliminated by the use of a Roux-Y segment of jejunum appeared to merit experimental study. Internal drainage of the common duct and pancreatic cysts into a limb of jejunum has been employed with satisfactory clinical results. The first concern in a consideration of the feasibility of duodenal stump management with a limb of jejunum is whether or not a leakproof anastomosis can be constructed. The anastomosis is unique in that it is not necessary to avoid compromise of the stoma between the duodenum and the jejunum. For

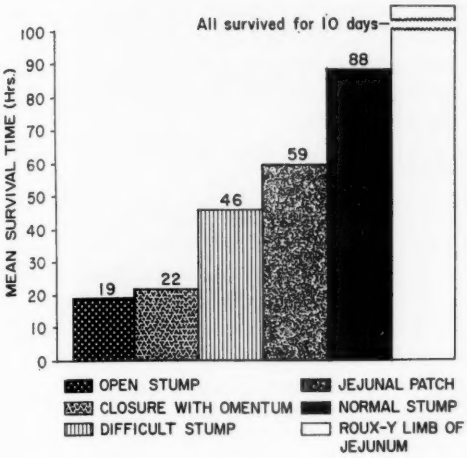

FIG. 9.

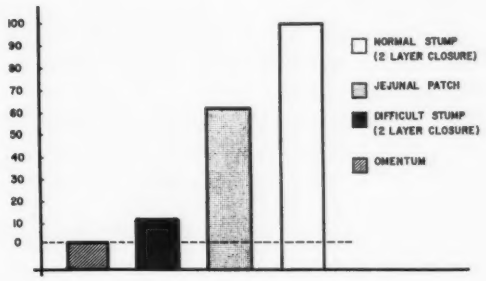

FIG. 10.

FIG. 9. Comparison of survival time in various group after afferent loop occlusion.

FIG. 10. Comparison of resistance of stump to leakage in various groups. Percentage of animals in which the stump held until the duodenal wall ruptured.

this reason, multiple rows of sutures may be used to enfold successive layers of the duodenum and jejunum, and thus the chances of leakage be markedly decreased. The pliable wall of the normal jejunum facilitates this maneuver so that complete capping of the rigid duodenum may be effectively executed. The security of this method of duodenal stump management is further supported by the results obtained in this study. In none of the animals was there evidence of leakage, even in those instances of afferent gastrojejunostomy limb occlusion in which the entire volume of pancreatic, biliary, and duodenal secretions was forced through the narrowed stoma.

Another theoretic potential complication of this method of stump management relates to the possible diversion of alkaline duodenal content into the Roux-Y arm of jejunum and away from the gastrojejunostomy stoma. This would, of course, predispose to the development of marginal ulcers. It was for this reason that a narrow duodenojejunal stoma was constructed by the placement of multiple layers of sutures. There is also a great tendency for stricture formation in defunctionalized anastomotic stomas with the passage of time. Late examination of experimental animals used in this study revealed stomal contraction as a consistent late change. Peristalsis of the duodenum also favors the movement of its content toward the gastroenterostomy stoma and therefore away from the direction of the jejunum. Additional evidence which upholds the resistance of this preparation to marginal ulceration was obtained as a result of histamine injections. The only animal which developed an ulcer had experienced afferent loop occlusion so that the duodenojejunostomy was serving as an effective route of duodenal decompression.

A distinct advantage of duodenal stump management by use of the Roux-Y limb of jejunum is the elimination of the necessity for extensive dissection and mobilization of the duodenal stump. This renders less likely the occurrence of damage to the pancreas and its ducts. There is also decreased likelihood of encroachment upon the common bile duct. Avoidance of extensive stump dissection saves enough time to more than compensate for the additional anastomosis that must be constructed.

Another advantage of this method of stump management is the avoidance of the necessity for forceful inversion of the thickened, rigid, unyielding duodenal wall. Excessive tension upon the suture line is thus avoided.

CONCLUSIONS

1. Two layer closure of the normal duodenal stump resists leakage very effectively when subjected to stress.

2. The "difficult" stump was found to be extremely susceptible to leakage in the presence of increased tension that follows a 2 layer closure.

3. The use of a jejunal patch for duodenal closure gave satisfactory results.

4. Viable omentum was ineffective when used to occlude the duodenal stump.

5. Management of the "difficult" stump with a Roux-Y segment of jejunum was attended by satisfactory experimental results and offered several advantages over other techniques which could be used under these circumstances.

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OPERATIVE EXPERIENCE WITH PATIENTS OVER 80 YEARS OF AGE

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IN THE FALL of 1831, at the age of 76, Chief Justice John Marshall travelled to Philadelphia in search of treatment for his agonizing bladder stones. Reluctantly, Dr. Philip Syng Physick agreed to operate upon him. In spite of the presence of a chronic liver ailment, a stomach full of food, inadequate premedication, no anesthesia, and the absence of antisepsis, the patient recovered uneventfully. Another 4 years transpired before the Liberty Bell knelled the death of the famous jurist.

In the past, surgical practice rarely extended itself beyond the barriers commonly thought to be imposed by old age. All too frequently the octogenarian has been denied the benefit offered by even the most refined operative techniques, and surgically correctible lesions have been allowed to progress to an irreversible state. One can only speculate upon the factors which influenced Physick to choose a positive approach in the treatment of a man who had already exceeded by 100 per cent the life expectancy at the time of his birth.

With ever increasing longevity, geriatric surgery is now a reality. The care of the geriatric patient is becoming a major surgical concern and, recently, a number of books devoted to this problem have been published. The importance of precise fluid administration, maintenance of blood volume, careful tracheal toilet, and early resumption of activity cannot be overemphasized. In many ways, the aged must be handled in the same manner as the newborn, with constant attention to the most minute details of preoperative and postoperative care. Surgical technique, however, remains essentially the same at any age; there is no substitute for careful, deliberate, gentle handling of tissues. In advanced age, there appears to be a particularly delicate balance between life and death.

Ziffren (7) has pointed out that since the first part of the twentieth century the number of persons 65 years and older has quadrupled, whereas, the general population has only doubled. More people now reach the age of 80 years, although, beyond the eighth decade life expectancy has not changed appreciably during the years. In 1900, the life expectancy at 80 was 5.1 years and in 1953 it was 5.4 years. It would appear, therefore, that the prophylaxis and treatment of disease in the older segment of our population has most appreciably benefited the group from 65 through 80 years of age. This study concerns those patients beyond the age of 80 admitted to the Baltimore City Hospitals for operative treatment.

MATERIAL

In the city of Baltimore there are 11,874 persons beyond the age of 80 (1960). With a population of 921,639, this would indicate that 1.3 per cent are 80 years of age and older. At the Baltimore City Hospitals, which is composed of 2,063 beds and consists of hospitals for the acutely and chronically ill, as well as a tuberculosis sanatorium and a home for the aged, the surgical service takes care of a large number of octogenarians, some nonagenarians, and an occa-

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This work was done during Dr. Fishbein's tenure of a Research Fellowship of the Heart Association of Maryland.

TABLE I.—OPERATIONS PERFORMED ON PATIENTS 80 YEARS OLD AND OVER

Types of operations	*No.*	*Total*	*Deaths— No.*	*Total*	*Mortality, per cent*
General surgical service		111		26	23.2
Herniorrhaphy—inguinal, hernial, umbilical	24		1		
Amputations: Digits	2		0		
Above knee	9		3		
Below knee	7		4		
Excision of local lesions	17		0		
Lysis of adhesions	6		1		
Subtotal gastrectomy	6		3		
Exploratory laparotomy	4		3		
Colectomy	4		2		
Small bowel resection	3		1		
Simple mastectomy	3		0		
Femoral embolectomy, with and without graft	3		2		
Closure of colostomy	3		0		
Gastrojejunostomy	2		1		
Incision and drainage of local abscess	2		0		
Colostomy	2		1		
Insertion of Thiersch wire	2		0		
Cholecystectomy and common duct exploration	2		1		
Incision and drainage of peritoneal cavity	1		0		
Lumbar sympathectomy	1		1		
Repair of hiatus hernia	1		0		
Exploratory thoracotomy and decortication of lung	1		1		
Enterostomy	1		0		
Appendectomy	1		0		
Open reduction of mandible	1		0		
Esophagostomy	1		0		
Resection of abdominal aneurysm	1		0		
Radical perineal resection	1		1		
Orthopedic service		82		26	31.7
Hip nailing, with or without plates	74		25		
Hip prosthesis	4		1		
Skeletal traction	3		0		
Wedge osteotomy	1		0		
Urologic service		60		13	21.6
Prostatectomies:					
Transurethral resections	31		8		
Suprapubic	8		1		
Retropubic	2		0		
Perineal	10		3		
Other transurethral procedures	3		0		
Pyelolithotomy	1		0		
Orchiectomies	5		1		
Ophthalmologic service		27		0	0
Cataracts	27		0		
Neurosurgic service		4		4	100
Trephines and decompressions	4		4		
Totals		284		69	

Mortality defined as any death occurring 30 days after operation or as long after operation as necessary to demonstrate recovery.

sional centenarian. This hospital is devoted principally to the care of indigents. Many patients, without family or friends, are in severe states of neglect, malnutrition, and dehydration upon admission. During the year 1959, 134 patients 80 years of age or older were admitted to this hospital. During the same year, 37 operations were performed on those aged 80 or over. This article concerns 207 patients over the age of 80 years admitted to the surgical service of the Baltimore City Hospitals in the 5½ year period from January 1955 to July 1960.

RESULTS

There were 207 patients 80 years of age or older who were operated upon from January 1955 to July 1960. Each year of this 5½ year period, an average of 37.6 patients in this category was admitted to the surgical service and underwent an average total of 51.6 surgical procedures. The figures to be given throughout represent the complete picture of all patients operated upon who were 80 or more years of age. None of the patients have been omitted. The only procedures which were omitted were bronchoscopies, esophagoscopies, cystoscopies, and aspiration biopsies. There were 132 patients between the ages of 80 and 84 years; 52 patients between 85 and 89; 14 patients between 90 and 94; 8 between 95 and 99; and 1 patient was 103 years of age. There were 116 males and 91 females; 161 white and 46 nonwhite patients. The average hospital stay of all the patients was 23.1 days. There were 284 operations performed upon 207 patients 80 or more years of age. Thirty patients were operated upon twice within the same hospital admission, and 6 patients underwent 3 operations during 1 hospital stay. No patient was counted more than once in the entire series, and operative procedures were listed according to the lesion found at operation. For example, an appendectomy was not counted when incidental to a gastrectomy or cholecystectomy. The mortality rate in these 207 patients was 33.3 per cent. Postmortem examinations were performed on 33 of the 69 patients who died, 47.8 per cent. The mortality rate based on the number of operations performed was 24.3 per cent. Mortality in this series is de-

fined as any death which occurred within 30 days after operation, or as long after as necessary to demonstrate failure of recovery or benefit from the surgical procedure. Included in the mortality calculations are all deaths, including those of patients who, shortly after operation, died from carcinomatosis or from overwhelming injuries.

Of the 284 operations performed, 46 were carried out under local anesthesia: cataract extractions, excision of skin lesions, and débridement of wounds. Of the 238 more extensive procedures, more than one-half involved orthopedic and urologic surgery; 78 of the patients underwent operation for fracture of the hip and 54 for prostatic enlargement and obstruction of the urinary tract. On the general surgical service, the most frequently performed operations were herniorrhaphy, embolectomy, subtotal gastrectomy, amputation, exploratory laparotomy for intestinal obstruction, bowel resection, and colostomy for carcinomatosis. By far, the greatest number of operations performed was for hernia (Table I).

Of the total of 284 operations, there were 111 general surgical procedures, 82 orthopedic procedures, 60 urologic procedures, 27 ophthalmologic procedures, and 4 neurosurgical procedures. The operative mortality rate was 24.3 per cent. The number of deaths for each surgical procedure is listed in Table I. The mortality figures reveal 23.2 per cent in general surgical procedures, 21.6 per cent in urologic procedures, and 31.7 per cent in orthopedic procedures. If only the extensive procedures are to be included in considering the general surgical mortality, the rate climbs to 28.1 per cent. There were no deaths resulting from less extensive surgery on this service, and 1 death in the 24 herniorrhaphies performed. This fatality occurred after an operation for a strangulated femoral hernia of the right side carried out under local anesthesia. The patient died of intestinal obstruction, and postmortem examination disclosed an unsuspected strangulated femoral hernia on the left side with necrotic bowel. The mortality rates for hip nailing and for prostatectomy were 33.8 per cent and 23.6 per cent, respectively. With the knowledge that death was inevitable without correction of the underlying problems, several of these patients were taken to the operating room in a moribund condition only after a period of several days of intensive therapy had failed to bring about improvement.

TABLE II.—PREOPERATIVE CONDITIONS DIAGNOSED CLINICALLY PRIOR TO SURGERY IN 207 PATIENTS

Preoperative condition	*No. of patients*
Cardiac	164
Pulmonary emphysema	119
Cerebral vascular insufficiency	64
Generalized arterial sclerosis	39
Malnutrition and dehydration	32
Benign prostatic hypertrophy, not because of admission	26
History of cerebral vascular accident	21
Urinary tract infection	17
Hernia, present	17
Anuria	15
Chronic lung disease	15
Diabetes	13
Pneumonia	11
Tuberculosis	10
Anemia	10
Cirrhosis	10
Osteoarthritis	9
Carcinoma	7
Paget's disease	6
Obesity	5
Parkinsonism	4
Chronic cholecystitis	4
Pleural effusion	4
Decubiti	2
Thoracic aneurysm	1
Goiter	1
Infection	1
Varicose veins	1
Leukemia	1

The various types of anesthesia used in these 207 patients were: 69 local, 108 spinal, and 107 general. Of the 69 patients who succumbed after operation, 13 had local, 21 spinal, and 35 general anesthesia.

An attempt was made to evaluate the preoperative concurrent illnesses of the 207 patients who were operated upon. A tabulation of the preoperative findings was recorded for each patient (Table II). Cardiac disease was the most frequent preoperative condition. All patients who had gross aberration as indicated by electrocardiograms or chest roentgenograms or who were found to have at least 2 clinical signs of heart disease, were considered to have cardiac abnormali-

TABLE III.—COMPLICATIONS AND CONDITIONS FOUND IN THE POSTOPERATIVE PERIOD IN 207 PATIENTS OVER 80 YEARS OF AGE

Condition	*No. of patients*
Cardiac	10
Dehydration and nutritional difficulties	10
Metabolic derangements "severe"	3
Gastrointestinal difficulties:	
Bleeding	3
Abdominal distention	8
Stress ulcers	2
Cerebral vascular insufficiency, disorientation	8
Cerebral vascular accidents	7
Bronchopneumonia	43
Aspiration and atelectasis	5
Urinary tract:	
Oliguria and/or anuria	7
Uremia	13
Urinary tract infection, excluding prostatectomies	6
Cystitis, necrotizing	1
Parotitis	3
Decubitus ulcer	7
Wound infections	13
Pulmonary embolism	4
Thrombophlebitis	1
Anemia	4
Wound hematomas, noninfected	2

ties. The next most frequent preoperative abnormality was pulmonary emphysema diagnosed either on the basis of roentgenologic examination or clinical evaluation. Benign prostatic hypertrophy frequently was encountered in patients operated upon for other reasons. Cerebral arteriosclerosis, generalized arteriosclerosis, malnutrition, and dehydration also proved to be common diagnoses in the preoperative evaluation.

A tabulation of postoperative complications is listed in Table III. Included is any postoperative difficulty which was encountered during the recovery period. Pneumonia was the most frequent postoperative complication while urinary tract conditions and infections were the second and the third most common postoperative states. In this group, there were 7 persons who had acute cerebral vascular accidents after operation. Six of these 7 patients succumbed. Pulmonary embolism was recognized in 4 patients, all died.

Of the 69 patients who died after operation, it was possible to account for the cause of death in 61 (Table IV). In those patients in whom the cause of death could not be determined, the postoperative notes usually described the conditions of the patients as poor and "going downhill" immediately after operation to the time of death. Without a postmortem examination, it was impossible to determine the cause of death or even the nature of the lethal process in these patients. In those instances in which the cause of death could be determined, pneumonia, the most common postoperative complication, was also the most common cause of death. In fact, diseases of the respiratory tract accounted for the majority of the postoperative deaths, 30.4 per cent. Four patients had cerebral trauma which required trephines and/or decompression procedures, all of whom died (Table IV).

DISCUSSION

In the 5½ year period from January 1955 through June 1960, 207 patients beyond the age of 80 years underwent 284 operations. This survey includes all the procedures except endoscopies and needle or superficial incisional biopsies. Included in the compilation are general surgical, orthopedic, urologic, ophthalmologic, and neurosurgical operations. Hip nailing, transurethral resection, and herniorrhaphy were the 3 most frequently performed extensive operations.

The experiences encountered in the operative treatment of patients beyond the age of 80 in a hospital caring principally for indigents serve to substantiate certain basic impressions. An overwhelming proportion of patients of this age had multiple coexistent disease states unrelated to the primary surgical condition when first seen. In many instances, the concurrent problems were of such a nature as to affect the prognosis for life even more unfavorably than the surgical illness itself. Seventy-nine per cent of our patients who arrived in the operating room had been given a diagnosis of heart disease, based on several corroborative diagnostic procedures. Similarly, 57 per cent bore the preoperative diagnosis of pulmonary emphysema. Other respiratory problems included recent or resolving bronchopneumonia, active or inactive tuberculosis, and

chronic tracheobronchitis. There was additional operative risk in a large group of patients exhibiting chronic, renal impairment or cerebrovascular insufficiency.

The preoperative preparation of the chronically ill or debilitated patient is influenced at the outset by the urgency of operation. Surgical conditions which require immediate definitive treatment limit the time available to correct any but the most obvious deficiencies. When dealing with elective procedures or when adequate temporizing measures are available in emergency situations, time may be available for leisurely correction of depleted blood volumes, nutritional deficiencies, metabolic and endocrine derangements, infectious processes, and anemias. Baseline evaluations of cardiac status, pulmonary reserve, renal function, and neurologic status are important in the preoperative appraisal of the elderly patient.

The anesthetic agent selected must give optimal analgesia, allow for adequate ventilation, insure the maintenance of preoperative blood pressure, and not interfere with cardiac rhythm. These requirements are universal and pertain to every patient, young and old. In the present series, major regional block in the form of spinal, saddle, or caudal anesthesia was used in 38.2 per cent of the operations, and only rarely was a supplementary inhalation anesthetic necessary to insure adequate analgesia. In 37.8 per cent of the operations, general anesthesia was administered. Likewise, in 24 per cent local infiltration anesthesia was selected. No definite conclusion could be reached in this series regarding the choice of anesthesia under a given set of circumstances, for in no instance could a definite relationship be established between the postoperative course and the anesthetic agent employed.

There was no significant difference in the average length of time that the patient was on the operating table between those who survived and those who ultimately died. In computing the duration of the anesthesia, all procedures performed under local anesthesia were eliminated. Two hours and twenty-four minutes represented the average time for anesthesia for the survivors, while 2 hours and 26 minutes was the average time for those nonsurvivors. General anesthesia, commonly thought to be fraught with hazard when administered to the very elderly patient becomes, in our opinion, relatively safe when adequate pulmonary ventilation and tracheobronchial suctioning are provided.

Several surgeons have alluded to the importance of distinguishing between elective operations and those generally considered to be emergencies. This differentiation is of obvious importance in the analysis of mortality statistics. There is not, however, an obvious distinction between those diseases which require immediate operative therapy, those demanding instant attention but which may be operatively corrected at a later date, and those which are electively treated at a predetermined time. Complete intestinal obstruction, leaking abdominal aneu-

TABLE IV.—CAUSE OF DEATH IN 69 PATIENTS OVER 80 YEARS UNDERGOING SURGERY

Cause	*No. of patients*
Respiratory tract	
Pneumonia	10
Pneumonia and uremia	2
Pulmonary embolus	4
Pneumonia and septicemia	1
Aspiration pneumonia	4*
Urinary tract:	
Pyelonephritis with uremia and GI bleeding	2
Pyelonephritis	1
Uremia with necrotizing cystitis	1
Bilateral cortical necrosis	1
Oliguria and uremia	1
Cerebral vascular accidents	6
Myocardial infarction	1
Carcinomatosis	4
Sepsis	1
Unrecognized lesion at time of surgery	3
Operative infection	1
Gastric atony with aspiration of tube feeding	3
Cerebral trauma	4
Cardiac arrest	1
Sudden, unexplained death	6
Progressive death requiring several amputation procedures	3
Peritonitis, secondary to perforation of rectum by enema tube	1
Undetermined	8

Mortality defined as any death occurring 30 days after operation or as long after operation as necessary to demonstrate recovery.
*Mucous plugs, 2.

rysm, and compound fracture are imperative situations which call for immediate surgical intervention. Uncomplicated inguinal hernia, hallux valgus, or hydrocele is obviously treated at the convenience of the patient and surgeon. Acute urinary retention with azotemia, caused by benign prostatic hyperplasia, is an emergency situation. However, the use of a urethral catheter makes prostatectomy an elective procedure. Similarly, hip fracture is frequently treated by internal fixation within several hours after injury. Some orthopedic surgeons, however, may defer operation 2 or more days. Because this disparity exists, no attempt has been made to classify the operations in this series as emergency and elective procedures.

The postoperative complication rate based on the number of patients, was 45 per cent. Morbidity during the convalescent period ranged from mild transient periods of abdominal distention or vomiting to moderately refractory conditions such as persistent urinary tract infection, bronchopneumonia, and congestive heart failure (Table III). Pulmonary complications affected the largest group of patients, while bronchopneumonia was the single most frequent respiratory infection after operation. Wound infections, inadequate nutrition and varying degrees of uremia consequent upon chronic renal disease or dehydration accounted for a significant number of postoperative complications.

When the 207 patients were categorized into groups having either one or more postoperative complications, or an uneventful convalescence, with unrecognized postoperative complications, the difference in mortality rate was strikingly apparent. In the former group the mortality rate was 61.3 per cent—93 patients, 36 survived and 57 died—while those patients with apparently routine postoperative courses exhibited a 10.5 per cent mortality rate—114 patients, 102 survived and 12 died. In these patients, death was due to sudden unrecognized fatal complications or unexplained causes.

The mortality rate in this report, 69 out of 207 patients, was 33.3 per cent, and for 69 of 284 operations, 24.3 per cent. Bosch and his associates published the results of their operative experience in a group of 500 patients 60 years old and over. This report pointed to a sharp increase in mortality after the age of 70 years. Forty-one of their patients were 80 years and older, and in this group 9 deaths were recorded, a mortality rate of 22 per cent.

Ziffren (7) reported upon a series of 429 patients beyond the age of 80 collected during a 10 year period. The mortality rate appeared to be 15.1 per cent, or 13.5 per cent when based on the total number of operative procedures. Childs and Mason reported a surgical mortality rate of 17.2 per cent in 99 patients over 70 years of age.

The divergence in the mortality rates obtained in these several studies may be explained by the diverse geographic, economic, and racial backgrounds of the patients comprising the various series, and, most important, the varying definitions of mortality.

In the present series, all patients who died from any cause within 30 days of operation were included in the mortality rates. Patients who appeared to be doing poorly on the thirtieth postoperative day and who continued to do poorly and died thereafter were also included. For instance, a patient who continued to suffer from one complication after another after operation and died on the forty-sixth day was considered a postoperative mortality. Also, many patients already doomed by the disease process were not excluded from the series. Thus, a patient who underwent an esophagostomy and gastrostomy during the terminal stages of carcinoma of the esophagus was included.

Bosch, and his associates define a surgical death as one which followed operation, regardless of the cause or time between operation and death, provided the patient was still in the hospital. Haug and Dale reported a 14.8 per cent operative mortality rate in patients 80 years and older. Their definition

of mortality applied to any patient who did not leave the hospital alive. It is obvious that in an institution which cares for the indigent and which has an acute, chronic, and old age service, there would be an exceedingly high mortality rate calculated on this basis, since many of the older patients are transferred to the chronic hospital and are not sent home. A voluntary hospital might have a low mortality rate if many patients were evacuated fairly promptly.

In the present series, the orthopedic and urologic procedures made up more than half the number of operations. The mortality rate in these is 31.7 per cent and 21.6 per cent, respectively. There are very few comparative series available in this age group. Byrne reported a 12 per cent mortality rate in 33 patients 80 to 89 years of age who had transurethral resection and suprapubic prostatectomy. These were private patients. Ziffren's (8) figures for this age group were better, 5 per cent for transurethral resection and 9.6 per cent for suprapubic prostatectomy. Olshamen and Miles reported a 14 per cent mortality rate in 203 patients between the ages of 70 and 80 years who had hip nailing. However, 45 patients were stated to have died later. The mortality rate for this group would then be 35 per cent. This increase in mortality clearly illustrates why, in advanced geriatric disease, the definition of surgical mortality should be extended to well over 30 postoperative days and should include the total effect of both the disease process and the surgical procedure. A study by Fitts and his associates of 108 patients treated for fresh fractures of the hip revealed a mortality rate of 6.5 per cent; however, the mortality rate before weight bearing was achieved rose to 26 per cent. The mean age for the group was 71½ years. The authors concluded that a 6 month mortality was a more realistic figure than the hospital mortality.

The effect of an operation upon a patient is hard to determine. Postoperative pneumonia, wound infection, hypovolemia, and atelectasis may easily be attributed to the procedure performed and to the preoperative and postoperative care. But what about the patient who has a myocardial infarction 3 weeks or 3 months after an operation? Can we properly assume that the stresses of hospitalization and operation had no effect on this patient and that he would have suffered myocardial infarction at this time, regardless of the operative procedure? Is the development of fatal pneumonia in an aged patient 3 months after the pinning of a fractured hip totally unrelated to the injury, the operation, or the period of hospitalization? It will be seen, then, that whereas in the younger age group immediate postoperative success is usually followed by ultimate recovery, in the aged patient, statistics related to immediate postoperative recovery are less informative and, certainly, do not give the over-all picture. Discussion of results of geriatric surgery must include the total effect of both the disease process and the operative procedure if the various forms of treatment are to be evaluated. Life expectancy over 80 years is still very short and must be considered in all decisions related to the aged. A mortality rate based upon death 30, 60, or even 190 days after operation would give a clearer evaluation of the results of operative procedures and would give an indication of the over-all effect of both disease and operation upon the aged. In this series, if mortality is extended to include any patient who died within 6 months after operation, the number of postoperative deaths jumps from 69 to 89 and the mortality rate to 42.9 per cent. One's depression at this realization is alleviated by such instances as: a patient of 96 who returned to the out-patient clinic for treatment of a skin rash after undergoing a left hip pinning at the age of 90 and a right hip pinning at the age of 93 years; an 80 year old male who survived closure of a perforated duodenal ulcer followed by a subtotal resection 12 days later for leakage from a second ulcer; an 89 year old patient who survived resection of a massive abdominal aneurysm.

There is little doubt that the over-all mortality rate in elderly patients is high. Many of these procedures, however, are not elective. The excellent results frequently achieved in these acutely ill patients encourages one to proceed. In fact, the postponement of elective procedures in elderly patients, either free of significant concomitant disease or not, is often unwise. Herniorrhaphy can be safely performed as an operation of election, but the treatment of an incarcerated and strangulated hernia, fraught with danger in any age group, is especially hazardous in the aged. There were no deaths in the series of elective herniorrhaphies. Elderly patients will tolerate most extensive operative procedures, provided the postoperative course is smooth and without operative complications. Efforts to improve preoperative and postoperative care, to shorten the time of surgical procedures, to find better anesthetic agents, to provide proper nursing care, to create a warm friendly atmosphere, and to establish rehabilitation units for the aged must be continued. The number of persons reaching the ninth decade of life and beyond is constantly increasing and the surgeon must be prepared to meet the challenge.

SUMMARY

1. An analysis is presented of 207 patients, beyond the age of 80, undergoing operations at the Baltimore City Hospitals during the years 1955 to 1960.

2. The over-all mortality rate, defined as any death which occurred 30 days after operation, or as long after the operation as necessary to demonstrate onset of recovery, was 33.3 per cent, or 24.3 per cent when based upon the number of operations performed. If follow-up study was extended to 6 months in all patients, the over-all mortality rate rose to 42.2 per cent.

3. Urologic and orthopedic procedures comprise approximately one-half the total number of operations performed. The mortality rates for the various services were as follows: general surgery 23.2 per cent; orthopedic surgery 31.7 per cent; urologic surgery 21.6 per cent; neurologic surgery 100 per cent with 4 traumatic emergencies.

4. Cardiac disease and pulmonary emphysema were the most frequent preoperative findings encountered in this age group.

5. Respiratory complications accounted for the majority of instances of postoperative morbidity and death.

6. With the short life expectancy in this age group and with an increase in morbidity and mortality occurring long after the usual postoperative period, emphasis is placed on a 30 to 180 day follow-up study for morbidity and mortality statistics.

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STUDIES OF CALCIUM AND MAGNESIUM METABOLISM DURING SURGICAL CONVALESCENCE

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METABOLIC CHANGES in human beings during surgical convalescence, as well as during times of response to other external influences, have been studied extensively. It has been generally agreed that the stimulation of the adrenal cortex and posterior pituitary under these circumstances plays an important role in the metabolic response during these periods. In more recent articles (3, 4), the role of the thyroid gland as an important link in this chain has been emphasized. An attempt has been made in this study to determine the role of the parathyroid gland in human metabolism during surgical convalescence. More specifically, studies have been made on the alterations in calcium and magnesium metabolism initiated by operative procedures.

METHODS

This investigation has been conducted in two phases. The first employs an intravenous calcium tolerance test as developed by Howard and his associates (6) to measure parathyroid activity. The response of the patient to a calcium load was evaluated by the criteria outlined by the same investigators (7). The second phase evaluates metabolic balance studies of calcium, magnesium, and nitrogen. The urinary excretion of corticoid metabolites was studied in conjunction with the latter as a reflection of adrenocortical activity. Normal controls were studied in conjunction with each group of patients.

Calcium tolerance tests. The amount of calcium used as a test load for each patient was determined by a calculation of the body surface by using a standard nomogram (7). The calcium was administered as calcium gluconate in an intravenous infusion of 1,000 cubic centimeters of 5 per cent glucose in water at a constant rate for 4 hours. Serum calcium determinations were made just prior to infusion, 0 hours; when half completed, 2 hours; at completion, 4 hours; 4 hours after completion, 8 hours; and 24 hours after infusion was begun. All determinations were made while the patient was in a fasting state. In 7 patients, a calcium tolerance test was performed on the day before and on the day after operation, to determine whether or not parathyroid gland activity, and thereby calcium metabolism, as measured by the calcium tolerance test, was affected by the operative procedure (Fig. 1). In 2 control patients, 20 units of ACTH were administered by similar intravenous infusion during a 4 hour period in lieu of operation, and calcium tolerance tests were performed on the day before and the day after such administration (Fig. 2). In 2 different control patients who had neither operation nor ACTH on the second day (Fig. 3) 2 calcium tolerance tests were performed during a similar 3 day period. This method was used to determine if the first calcium load might affect the response to the second within this short period of time.

Metabolic studies. Metabolic balance studies were carried out in 3 patients undergoing operation (Figs. 4, 5, and 6), and in 1 control (Fig. 7). Patients received constant-value diets based upon total body surface and consisting of 2,250 calories, 15 grams of nitrogen, and 100 to 150 milligrams of calcium per 1.73 square meters of body sur-

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Supported by grants from the Josiah Macy, Jr. Foundation and the U. S. Public Health Service (A-2722 [R 1]) and aided by a contract between the Office of Naval Research, Department of the Navy, and Yale University School of Medicine, NR 105057.

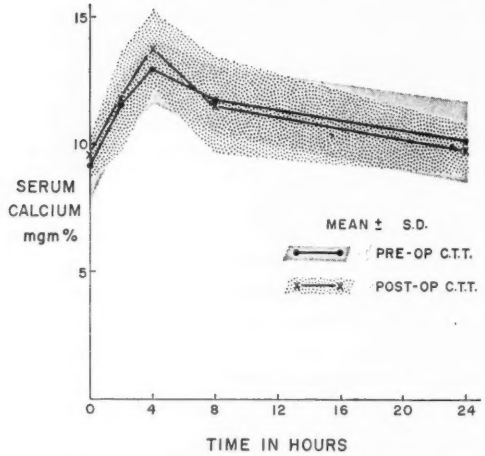

FIG. 1. Calcium tolerance tests, test group. Mean values charted. S. D., standard deviation. C.T.T., calcium tolerance test.

face. Distilled water was given orally ad libitum. All diets were formulated by one dietitian whose work was confined to these metabolic studies. The patients were encouraged to consume the entire diet daily, thus avoiding fractional calculation of dietary constituents. At random intervals during each patient's study, a second identical diet was prepared; this diet was then homogenized and analyzed as to the content of the dietary constituents being studied. Results were compared with the figures used in the calculation of the diets, and correlation was found to be very good in each instance.

Twenty-four hour urine specimens were collected daily and kept under refrigeration. Specimens were then acidified with 5 cubic centimeters of acetic acid per liter and an aliquot was frozen for analysis. Feces were refrigerated in a glass container and were collected in 3 to 6 day aliquots. Collection periods were identified by the administration of 0.6 gram of carmine alum lake orally at predetermined intervals. Fecal specimens were then frozen. Later each specimen was homogenized and diluted, and an aliquot was used for analysis. Calcium and magnesium determinations were made by a photometric procedure similar to that described by Fales. Nitrogen determinations were made by the micro-Kjeldahl method using a selenium catalyzer and urinary corticoids by the method of Gornall and MacDonald.

These studies were carried out on a hospital division in which the personnel had been specifically instructed in the care and attention needed to conduct metabolic studies of this nature. Control patients, as well as those undergoing operation, were placed at complete bedrest for the entire duration of the studies, including both the preoperative and the postoperative periods. A 3 day adaptation to the diet and general regimen was followed by a 6 to 11 day preoperative control period and a 6 to 8 day period of postoperative study. None of the patients received nutrients orally on the day of operation nor for 3 days thereafter, but intravenous fluids were given which contained none of the constituents studied during this period. Then, all patients were able to resume their full preoperative diet. The control patient was given preoperative preparation and medication identical to that administered to the patients undergoing operation. The former received 20 units of ACTH by intravenous drip in lieu of operation, and 20 units of ACTH intramuscularly every 6 hours, then every 8 hours,

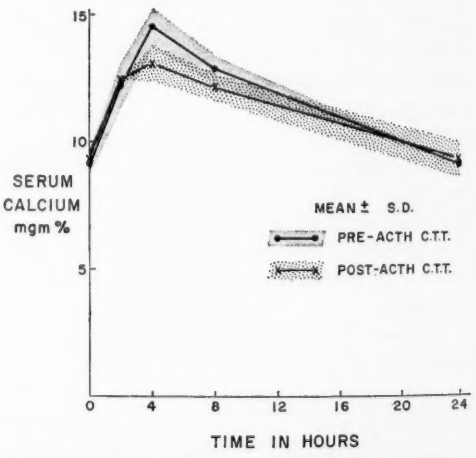

FIG. 2. Calcium tolerance tests, controls given ACTH.

on the subsequent 2 days in order to simulate adrenocortical stimulation brought on by an operative procedure.

RESULTS

The responses of the patients studied are shown graphically. In Figure 1, the results are given for the calcium tolerance tests in the test group. It has been determined by routine statistical analysis that although there is a significant difference in the mean preoperative and postoperative values, $p < 0.001$, there is nothing to indicate that these differences are due to changes in parathyroid function in patients subjected to operative trauma. There was no statistically significant difference, $p = 0.1\text{-}0.25$, in the 2 calcium tolerance tests performed on each patient in the control groups (Figs. 2 and 3). This finding implies that calcium metabolism, or at the least the output of parathormone, is not altered by anesthesia and operation. This opinion appears to be borne out by an examination of the results of the metabolic study (Figs. 4, 5, and 6). While urinary calcium remains relatively unaffected, there is an increase in fecal calcium up to 100 per cent during the postoperative period with a generally lesser, but still constant, increase in fecal magnesium, while the urinary magnesium remains relatively unchanged. These changes do not seem to be correlated with the adrenocortical response as measured by urinary corticoids since, in fact, there was no increase at all in urinary corticoids in 1 patient. In the control patient (Fig. 7), there was a significant increase in urinary corticoids in response to the administration of ACTH, but no significant increase in fecal calcium, and actually a decrease in fecal magnesium.

DISCUSSION AND CONCLUSIONS

Most of the increased calcium loss in these patients after trauma appeared to be by the fecal route. It has been accepted that calcium excretion in the feces is relatively unaffected by parathormone. That some other metabolic mechanism besides increase

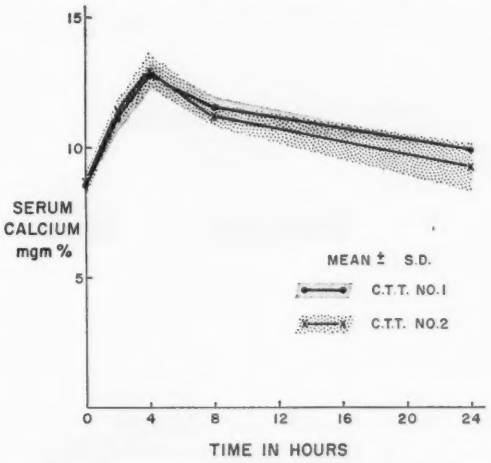

FIG. 3. Calcium tolerance tests, controls not given ACTH.

in parathormone production is responsible for changes in calcium metabolism during surgical convalescence is borne out by the results of the calcium tolerance tests. Increased adrenocortical activity, likewise, does not appear to play a major role in this change. This finding cannot be correlated with negative nitrogen balance following operation since in our patients nitrogen lost by the fecal route seems to remain relatively constant. It is noteworthy that all patients demonstrated a loss of calcium in the feces even when there was no calcium intake, either orally or parenterally, and in most patients, the fecal calcium during the postoperative period, after resumption of dietary intake of calcium, exceeded that intake significantly. Therefore, it is concluded that an increase in fecal calcium during the postoperative period is due both to a decrease in the calcium absorption in the gastrointestinal tract and to an increase of the calcium excretion into the gastrointestinal tract. Since calcium is absorbed from the upper small intestine, chiefly the duodenum, and its absorption is governed in great part by hydrogen ion concentration in the intestine, especially under conditions of constant vitamin D intake and unchanging dietary composition, it is considered

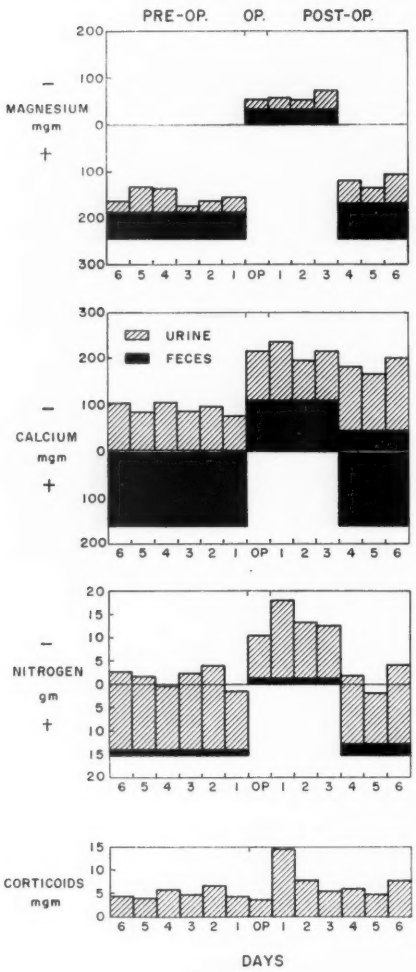

FIG. 4.

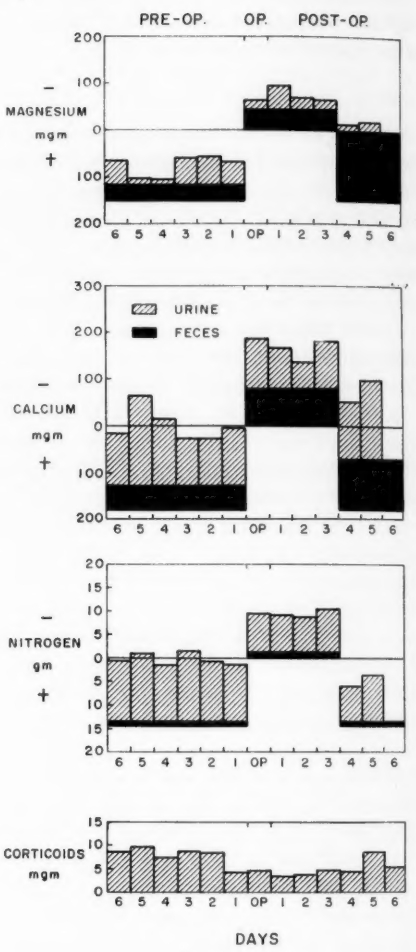

FIG. 5.

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that altered acidity in the upper small intestine during the postoperative period might play a significant role in this change. Calcium excretion by the liver and the epithelium of the large bowel may also be altered, but the differentiation of these factors in fecal calcium content is most difficult, if not impossible, to determine with accuracy. Increased thyroid activity after operation may also play a part in this increase of fecal calcium, since under conditions of increased thyroid activity, there is a decrease in calcium absorption. That the magnitude of the operative procedure may be somewhat responsible for this calcium loss is suggested by the fact that the increase in fecal calcium, both absolutely and according to percentages, was greatest in the patient who underwent most extensive operation (Fig. 6).

Changes in magnesium metabolism do not appear to be as impressive as those of

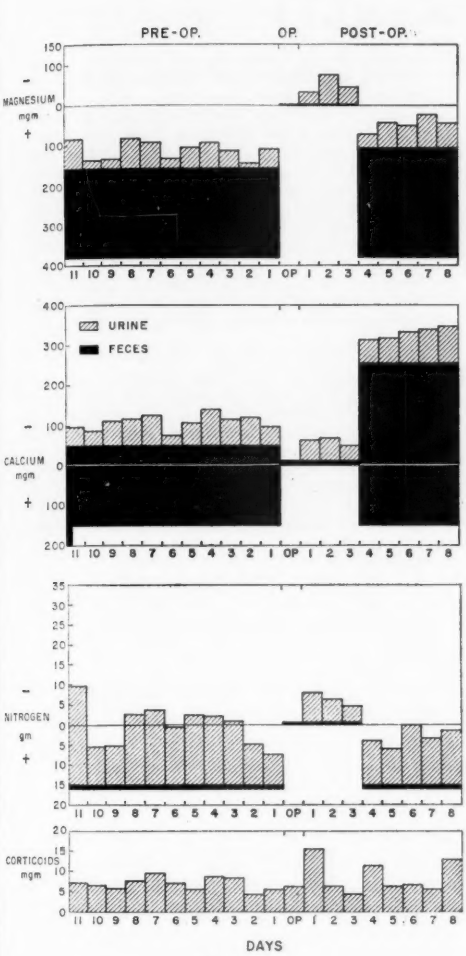

FIG. 6.

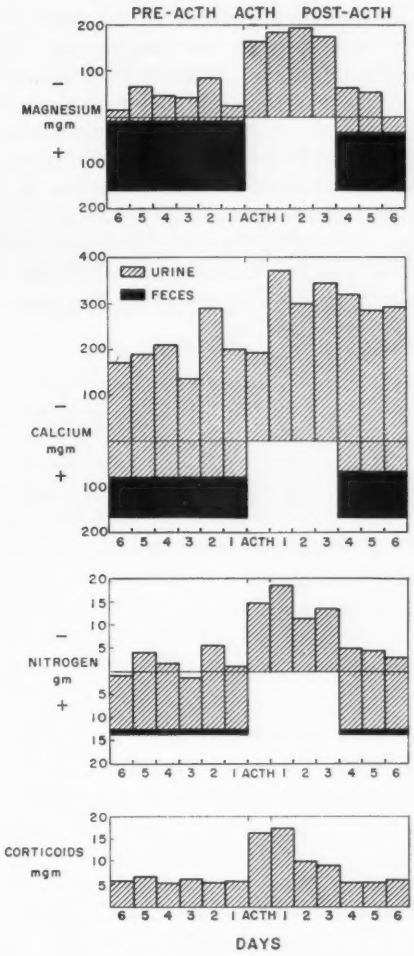

FIG. 7.

FIGS. 4 to 6. All patients were healthy adults operated upon under general anesthesia. The operations were: 2 inguinal herniorrhaphies and 1 pneumonectomy (class 3-7—Moore and Ball). The metabolic data are presented after the method of Reifenstein, Albright, and Wells.

FIG. 7. Metabolic studies on control patient, a healthy medical student.

calcium metabolism in the postoperative patient. Except for 1 patient who demonstrated a great increase in fecal magnesium postoperatively, all patients remained in positive magnesium balance with relatively minor changes in magnesium lost during the postoperative period. The recent work of Barnes, Cope, and Gordon suggests that except under circumstances of unusual magnesium losses, particularly from the small bowel, changes in body content of this ion are minimal and play a minor or insignificant role in normal surgical convalescence. Even though in certain pathologic states there is an apparent reciprocal relation between serum levels of calcium and magnesium, the metabolism of these two ions is thought to be governed by different enzyme and endocrine factors.

Of what significance these changes may

be is open to speculation. It appears from these studies that the parathyroid gland itself is relatively unaffected by trauma to other parts of the body and that alterations in calcium balance as demonstrated by these studies are due rather to changes in calcium absorption and excretion in the gastrointestinal tract. This results in a negative calcium balance in the postoperative period which is more pronounced than the negative balance produced by only bed rest.

SUMMARY

1. The metabolism of calcium and magnesium has been studied in the preoperative and postoperative periods.

2. Parathyroid function appears to be relatively unaffected by operative trauma.

3. There is a negative calcium balance in the postoperative period, principally due to fecal calcium loss.

4. Magnesium metabolism is not altered significantly in the postoperative period.

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THE SIGNIFICANCE OF URINARY TRACT COMPLICATIONS IN CARCINOMA OF THE CERVIX UTERI

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PROGRESS has been made on two broad fronts in the management of carcinoma of the cervix. Early diagnosis has been advanced by the education of patients and doctors and by the application of exfoliative cytology. Treatment itself has been advanced not so much by the development of any new or radically improved form of therapy as by centralization of cases in large clinics where the long established tools of radiotherapy and surgery are applied with greater refinement than heretofore. Cosbie has reviewed the progress made in Ontario during the period of 1933 to 1953 showing an improvement in survival rate from 32 per cent to 45 per cent. One of the refinements in the care of women with carcinoma of the cervix is the investigation and management of complications of the urinary tract. Attention has recently been drawn to this subject by the excellent review of Kickham which is based on an even larger experience than the present series. The scope of the present study is deliberately limited in order to bring out certain facts concerning the natural history of the disease.

The urinary tract may be involved by the carcinoma of the cervix or may be injured in the course of treatment of the disease by radiation or by surgery. As this study deals with patients treated primarily by radiation it does not include consideration of damage to the urinary tract by surgery. It will, furthermore, be shown that few if any of the patients here reported upon had any injury to the urinary tract by radiation. The series, therefore, consists almost entirely of cases of urinary tract complications due to carcinoma of the cervix as such.

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This study was in part supported by the Ontario Cancer Treatment and Research Foundation.

CLINICAL MATERIAL

The patients were from the Ontario Institute of Radiotherapy and the Department of Radiotherapy of the Toronto General Hospital.[1] They were all women with proved and staged primary carcinoma of the cervix uteri, treated in the clinic during the years 1950 to 1955 inclusive. There were 735 consecutive cases observed for from 3 to 8 years. All patients were treated primarily by radiation—radium and roentgen rays combined or by roentgen rays alone. Roentgen ray treatment was by high voltage—400 kilovolts—until 1953 when it was supplanted by radioactive cobalt.

Urologic investigation by intravenous pyelography and cystoscopy was carried out routinely on all new patients prior to treatment. This was repeated later when indicated by the clinical course or findings. I saw the majority of these patients personally and attended all of the patients with complicated cases who required urologic care in consultation with radiotherapist and gynecologist.

By urinary tract complication is meant: (1) ureteral complication, when there is evidence of obstruction of the ureter on intravenous or retrograde pyelography, uremia, or oliguria and (2) bladder complication, when there appears to be infiltration of the bladder on cystoscopy or when a vesicovaginal fistula is present, and finally (3) urethral involvement.

Apparent bladder involvement on cystoscopy was confirmed by biopsy in only

[1]Moved to new quarters in May 1958 to become the Ontario Cancer Institute incorporating the Princess Margaret Hospital.

the few cases in which an anterior exenteration was contemplated. In cases of vesicovaginal fistulas and urethral involvement biopsy was usually performed and malignancy was always found.

Early or late radiation cystitis, telangiectasis, and incidental urinary tract disease have not been included as complications in these statistics. Fistulas and other complications occurring after hysterectomy in patients who had first been treated by radiation are also not included in this series.

During the period from 1950 to 1955 almost all patients in the communities served by the clinic were treated primarily by radiation; only occasional patients with stage I carcinoma of the cervix were treated primarily by surgery. The series is therefore representative. The treatment was uniform, the only change being the introduction of the cobalt bomb in 1953.

INCIDENCE, SITE AND TIME OF INVOLVEMENT OF URINARY TRACT

Urinary tract complications of carcinoma of the cervix as defined occurred in 123 of the total of 735 patients, an over-all incidence of 17 per cent. The distribution of patients and the incidence of complications for each stage (World Health Organization staging) were as follows: stage I, 244 patients, 17 or 6.5 per cent with urinary tract complications; stage II, 270 patients, 36 or 13 per cent with urinary tract complications; stage III, 163 patients, 41 or 24 per cent with urinary tract complications; stage IV, 58 patients, 29 or 48 per cent with urinary tract complications. As might be expected the frequency of complications rises in geometric progression with the stage of the disease: approximately 6, 12, 24, 48 per cent for stages I, II, III, IV, respectively. Not too much significance can be attached to the exact distribution of these complications by stage, however, as this may be expected to vary from clinic to clinic depending on different staging practices. The over-all incidence of 17 per cent represents chiefly patients involved initially or early by some urinary tract complication. The incidence of ureteral, bladder, or urethral involvement in patients with carcinoma of the cervix classified as stage I or II indicates the extent to which pyelography and cystoscopy may detect spread of the disease not apparent on clinical examination.

The site of involvement of the urinary tract in the 123 cases was: ureter alone in 59 cases, ureter and bladder in 38, and bladder alone in 26 cases. The ureteral involvement was bilateral in somewhat less than half of the 97 cases. The obstruction was sometimes shown to be at the ureterovesical junction, particularly in patients in whom the bladder was also involved. In other patients the obstruction was shown to be at the pelvic brim. In many instances it was not considered expedient to make this determination if it involved retrograde pyelography.

Bladder involvement was of the bladder wall, apparent on cystoscopy in 38 patients, a vesicovaginal fistula in 20, and of the urethra, proved in 6 patients.

Certain clinical features of these complications cast light on their nature. One of these is the time of appearance of complications. In the cases of ureteral obstruction this was present in half of the patients initially, in another quarter in the first year, and in one-quarter it appeared later. Bladder involvement tended to appear even earlier, being present in two-thirds of the involved patients initially, in one-quarter in the first year, and in a few appearing later.

Another clinical feature was the frequent involvement in the same patients of other structures as well as of the urinary tract: nerve root in 16 patients, bowel in 9, and other structures in 12 patients. These constitute about 30 per cent of the 123 complicated cases. In many instances, these additional complications were not recorded. A common and tragic triad was that of ureteral obstruction with femoral nerve root pain and lymphedema of the leg. Patients who have some involvement of the urinary tract should be questioned and examined closely for other complications in order to

make a complete assessment of the case and also to clarify the nature of the urinary tract involvement.

Another feature of these cases is noteworthy, namely the age of the patients in whom these complications arise. The age at death of the patients with urinary tract complications was compared with the age at death of the total group (Fig. 1). It appears that the group with complications die on an average of 4 years earlier. This observation confirms the clinical impression that child brides in whom carcinoma of the cervix develops in their twenties terminate on a urologic service in their thirties with malignant vesicovaginal fistulas, ureteral obstruction, nerve root involvement, and lymphedema.

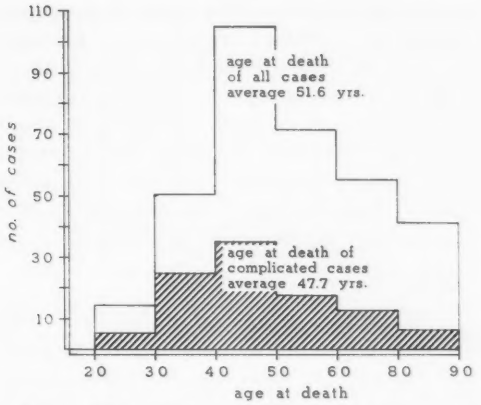

FIG. 1. Effect of urinary tract complications on age at death in cervical carcinoma.

PROGNOSIS

The incidence, distribution, site and time of appearance, and other clinical features of urinary tract involvement in carcinoma of the cervix have been noted. The data on survival are of even greater significance. In a comparison of the 3 year survival rates by stages for the total group and the group with urinary complications the most profound effect on prognosis was noted in stages I and II, the survival rates being reduced from 73 to 30 per cent and from 53 to 11 per cent, respectively. In stage III the rate falls from 29 to 12 per cent. In stage IV the prognosis is already so poor, 7 per cent, that the addition of urinary tract involvement matters not. The 3 year survival for all stages is reduced from 50 per cent for the total group to 13 per cent for the complicated group.

The approximate 3 year survival rates of patients according to site of involvement of the urinary tract were: 20 per cent for ureter alone, 10 per cent for bladder alone, and 5 per cent when both ureter and bladder were involved.

EFFECT OF SURGERY ON SURVIVAL

Anterior exenteration for proved involvement of the urinary bladder by carcinoma of the cervix has been performed only on exceptional patients in this series. One patient has survived for 9 years. Survival rates would probably depend very much on the selection of cases for curative surgery.

Palliative surgery for vesicovaginal fistula was carried out in the form of ureterosigmoid transplant in 4, cutaneous ureterostomy in 5, and nephrostomy in 3 patients while nothing was done for 8 of these 20 patients. Patients in both groups were all dead in 2 years which indicates that only simple forms of urinary diversion are justified in the palliation of malignant vesicovaginal fistulas.

Operation on patients with ureteral obstruction might, on the other hand, be expected to have some effect on survival, ureteral obstruction being often considered an important factor in the mortality of patients with this disease. Of the 97 patients with ureteral involvement, ureterosigmoidostomy was performed in 10 cases, cutaneous ureterostomy in 5, and nephrostomy in 5, whereas nothing was done in 77 cases. Of the 20 patients operated upon, 16 were alive at 3 months, 13 at 6 months, 7 at 1 year, 4 at 2 years, and 2 at 3 years. Of the 77 not treated, 50 were alive at 3 months, 38 at 6 months, 22 at 1 year and at 2 years, and 11 at 3 years. One cannot help but believe that life was surely pro-

longed for a few months in some of the patients, but the data show that any prolongation of life must have been very limited. Apparently, a number of patients with gross obstruction of ureters survived without surgical interference for many more months than was anticipated and patients upon whom operation was performed died of cancer in spite of restored renal function.

COMMENT

The urinary tract complications in 123 patients appearing in a consecutive series of 735 cases of carcinoma of the cervix treated primarily by radiation have been defined as: ureteral obstruction, cystoscopic evidence of bladder invasion, vesicovaginal fistula, and urethral invasion. Such complications occurred in 17 per cent of the series, less commonly in early stages and more commonly in later stages: stage I, 6 per cent; stage II, 13 per cent; stage III, 24 per cent; and stage IV, 48 per cent. Lateral spread to the ureter was the commonest form of involvement—97 cases—forward spread to the bladder next—54 cases—and downward spread to the urethra the least common—6 cases.

The incidence of these complications is sufficient to indicate routine urologic investigation by pyelography and cystoscopy in all new cases of carcinoma of the cervix of whatever stage in order to make a complete assessment of patients with this disease. To attempt to confirm bladder involvement by biopsy is not practicable as a routine, being fraught with the hazard of creating a fistula. Cystoscopic appraisal of bladder invasion is usually accurate but must be confirmed by biopsy when exenteration is contemplated. Intravenous pyelography has become a valuable tool in the assessment of any doubtful pelvic disease, and particularly in carcinoma of the cervix. It may fail to define the exact level of obstruction if the hydronephrosis is very advanced or the kidney is nonfunctioning. Unless operation is contemplated, usually an attempt is not made to ascertain the site of obstruction by catheterization of the ureter and retrograde pyelography for fear of stirring up a quiescent hydronephrosis and creating indications for surgical intervention. The value of intravenous pyelography is its ability to reveal early lateral extension of tumor or lymph node involvement before it is possible by physical examination.

If there is doubt about the significance of the findings on urologic investigation a certain amount of light is shed by the associated features. The presence of other complications such as nerve root involvement and lymphedema of the leg suggests that the urinary tract complication is of a malignant nature. Here it may be noted that if the pain considered due to an obstructed ureter extends below the inguinal ligament onto the thigh, it is caused by associated femoral nerve root involvement and will not be relieved by surgery of the ureter or kidney. Leg swelling in these patients is rarely due to venous thrombosis but to blockage of lymphatics by tumor and usually accompanies femoral nerve root pain and ureteral obstruction.

EFFECTS DUE TO RADIATION

The acute effects of radiation of the urinary tract in this series of 735 patients were mild to moderate during and immediately after treatment and rarely necessitated urologic consultation. The records are not sufficiently accurate to give any incidence of acute radiation cystitis. The delayed effects of telangiectasis and cystitis were seen 6 months to several years later. Cases of hematuria were usually controlled with urinary antiseptics. As cystoscopy is not routinely repeated after a stated interval, it is again not possible to give the incidence of such effects. More advanced radiation effects producing a white patch of necrosis on the trigone or posterior wall of the bladder have been seen in about a dozen patients during the past 10 years, but all of them were treated before 1950, and usually before 1940. After several years of observation, 10 years in 1 patient, such bladders

have been found to break down and form a benign vesicovaginal fistula. These are the fistulas which are believed to be due to excessive radiation. None of the patients in this series, however, exhibited radiation necrosis or fistulas during the 3 to 8 years of follow-up. As the fistulas observed have developed 10 to 20 years after treatment, there is a possibility of such occurrence in future years in this series also. The absence of radiation necrosis in the present series, however, would suggest that few of these patients are likely to have a radiation fistula in the future. The 20 vesicovaginal fistulas recorded in this series were all obviously malignant and confirmed by biopsy in some. All patients were fortunately dead in 2 years. The only possible conclusion is that there has been little serious effect of radiation on the bladder in this series.

Ureteral obstruction in patients with carcinoma of the cervix treated by radiation has often been ascribed to the treatment. Such has not been our experience during the past 10 years and is not borne out by the data on the present series. To begin with, in one-half of the patients the condition was present initially, in one-quarter it developed in the first year and in another quarter later; 80 per cent of these patients were dead of carcinoma in 3 years. Of a score who had undergone an exploratory operation in the last 10 years all but 1 were found to have carcinoma. Some of the 20 per cent who have survived more than 3 years may have been cured of their disease and left with radiation fibrosis of the ureter. The natural history of carcinoma of the cervix would indicate that a number of these patients will yet succumb to the disease. In our opinion ureteral obstruction occurring in women who have had radiation therapy for carcinoma of the cervix is almost always due to the disease rather than the radiation. Careful scrutiny of the patient for evidence of associated nerve root involvement or lymphedema of the leg will confirm this fact in many and the subsequent clinical course in most.

PROGNOSIS WITH PALLIATIVE SURGERY

Only palliative surgery was performed for vesicovaginal fistulas, and no effect on survival was expected. All patients were dead in 2 years with or without surgical treatment. Only the simplest forms of urinary tract diversion would appear to be indicated, and ureterosigmoid transplantation is preferred unless there is any threat of rectal complications.

The complete failure to prolong life by urinary tract diversions for obstructed ureters is of interest; 20 patients operated upon lived no longer than the 77 patients who were not operated upon. Involvement of the ureter by carcinoma of the cervix apparently has a biologic significance to the patient which extends beyond its mechanical effect on urinary drainage. It indicates the presence of an invasive tumor of a lethal character. The associated clinical features of urinary tract complications of carcinoma of the cervix—frequent involvement of other structures, early time of appearance of the disease, short survival at any stage of the disease, and the inability to prolong life by diverting obstructed ureters—all point to a particularly malignant form of carcinoma of the cervix. Even the fact that these patients die at an earlier age suggests that there is a biologic difference in the carcinoma.

POLICY OF MANAGEMENT

The first policy of the management of urinary tract complications of carcinoma of the cervix is to make a very careful and complete assessment in each complicated case on the basis of all possible relevant considerations. The stage or extent of disease, its duration and apparent rate of growth, the exact effect on the urinary tract, possible involvement of other structures, the patients' age and general condition, and her social, domestic, and economic circumstances together with any other factor are considered. Such a patient is usually examined under a general anesthetic jointly by the responsible radiotherapist, urologist, and gynecologist at which time the considera-

tions mentioned are reviewed, and an agreement is sought as to the most satisfactory management. Seriatim consultations by deputies or in the absence of other responsible parties are not an adequate substitute for a joint conference on a problem case.

1. Involvement of the urethra usually produces urinary retention for which an indwelling balloon catheter is used. Only occasionally is it possible to give further irradiation; this has relieved the obstruction in some cases. In young patients who appear to have a longer life expectancy, ureterosigmoid transplantation has been performed in a few instances. The bladder must then be irrigated at intervals to prevent empyema. Occasional patients may be candidates for an anterior exenteration.

2. Cystoscopic evidence of bladder infiltration is also observed closely for possible indications of anterior exenteration. This is not indicated if the patient also has ureteral obstruction and certainly not if there is also nerve root pain or lymphedema of one leg. Exenteration is avoided if pelvic examination indicates marked extension of the tumor laterally and also in older patients. With such limited indications only a handful of patients suitable for exenteration have been observed in the past 10 years. In some of these biopsy of the bladder was not performed, and no evidence of bladder involvement by tumor was found at operation. Biopsy is thus essential to confirm bladder involvement if this is to be the indication for anterior exenteration. Urinary diversion in the few cases in which it was carried out has been by ureterosigmoid transplantation, sometimes with a defunctioning colostomy. While the complications of ureterosigmoidostomy are recognized there are still a number of features to recommend this procedure instead of an ileal conduit to the abdominal surface. Not the least advantage is the surgical simplicity and ease of a transplant.

The majority of patients with apparent bladder involvement are not considered candidates for operation, and biopsy is not performed but they are followed up.

3. Vesicovaginal fistula ranks with hemorrhage and nerve root pain as that which women fear in cancer. Palliation, unless the patient is in a terminal state, is mandatory. Whatever surgical means are required to render the patient dry are welcomed by the patient. In order of preference, ureterosigmoid transplantation is considered unless contraindicated by rectal involvement by carcinoma and fear of rectovaginal fistula, or unless there has been radiation proctitis which results in uncontrolled diarrhea or incontinence of urine, or the patient is too old to tolerate the reabsorption of urine from the bowel or maintain rectal continence. As a second choice, one ureter may already be closed off or almost completely occluded to permit unilateral cutaneous ureterostomy. Bilateral ureterostomy is the next choice. If the patient also has bowel involvement with a colostomy, there is no hesitation to perform a cutaneous ureterostomy or nephrostomy on one side and nephrectomy on the side of the colostomy rather than to give the patient 3 new stomas. An ileal conduit might be justified in such an instance. Occasionally if the fistula is not too large, it may be possible to keep a patient reasonably dry with a large indwelling catheter. This may be worth a trial in the older or terminal patient. At the other end of the scale, there may be a younger patient with a sufficiently limited lesion to permit consideration of an anterior exenteration.

4. Ureteral obstruction, if unilateral, may be asymptomatic; but if pain is produced this is usually controlled with moderate sedation for a month or two until the obstruction has become complete and the kidney has ceased to function. If the pain is more severe or lasts longer it is usually due to associated nerve root involvement. The policy with unilateral ureteral obstruction is conservative. If there is bilateral ureteral involvement, one kidney is usually completely nonfunctioning and the other grossly hydronephrotic. The choice of treatment in order of preference may then be to consider external radiation first. It occasionally relieves

the obstruction. If this is not applicable it may be well to consider whether anything should be done at all. If the patient is old or the disease extensive with nerve root pain and lymphedema, it may be better to withhold treatment. If the patient is young with a young family, she and her family may wish to see life prolonged by even a few months. The simplest diversion is reimplantation of the ureter into the bladder when this is possible. Next to be considered is an ileoureteroplasty, bypassing the obstructed segment of ureter with an isolated loop of ileum. These operations have the advantage of avoiding the creation of an external stoma but are only applicable if the condition of the patient's own bladder is satisfactory. Ureterosigmoid transplantation may be the next alternative to consider if the condition of the rectum permits. Sometimes the ureteral obstruction is at such a high level that ureterosigmoidostomy is not possible, and nephrostomy may be required. If a cutaneous ureterostomy or nephrostomy is required, usually it is performed only on one side, preferably the right in order to permit a possible later colostomy on the left side.

The use of an ileal conduit to the skin is chiefly indicated without much alternative after the superradical procedure of total pelvic exenteration. When the patient still has an intact rectum and a urinary diversion is required, there is a choice of an ileal conduit, a rectal bladder, or a ureterosigmoid transplant. If the patient has a long life expectancy the more physiologic ileal conduit must be considered in spite of its being a more elaborate surgical procedure and creating an incontinent cutaneous stoma. A rectal bladder is a simpler surgical procedure, physiologically sound and easier to manage. If the patient has a more limited prognosis, which is the case in the vast majority of patients who require urinary tract diversions due to involvement by carcinoma of the cervix, the even simpler surgical procedure of ureterosigmoidostomy is preferred though the morbidity due to pyelonephritis and hyperchloremic acidosis is admitted. If the carcinoma is so advanced that the choice is between cutaneous ureterostomy and an ileal conduit, it is considered too late to engage in the more elaborate procedure for the sake of any physiologic advantage which an ileal conduit may have over an intubated ureterostomy during the few months of life that the patient has left.

The generally conservative surgical policies outlined are based on 10 years of experience in being responsible for the terminal care of many patients with carcinoma of the cervix. Other urologists may arrive at different conclusions and different policies of management but in so doing will have to take into account the established facts of natural history of the disease of carcinoma of the cervix involving the urinary tract which this study has described.

The review of our experience, far from giving any answers to the problems of carcinoma of the cervix, has focused attention on a group of patients particularly difficult to treat. While on the one hand the poor prognosis of these patients was used to justify our conservative policy of management, on the other hand a more aggressive lead should also come from the findings presented. Perhaps the patients with carcinoma of the cervix with urinary tract complications should, in view of their poor prognosis, be submitted to an even more intensive study. The clinical features associated with urinary tract involvement, particularly in respect to prognosis, suggest a biologic aspect of the disease in these patients which merits further study that might lead to more constructive forms of treatment.

SUMMARY

1. Of 735 consecutive patients with carcinoma of the cervix treated by irradiation and followed up for 3 to 8 years, urinary tract complications occurred in 123 or 17 per cent.

2. The complications consisted of: ureteral obstruction in 97 cases almost half of which were bilateral; on cystoscopy apparent involvement of the urinary bladder by carcinoma in 38; malignant vesicovaginal fistula

in 20; and urethral infiltration by carcinoma in 6 cases. In 38 of these cases there was involvement of both ureter and bladder.

3. The complications increased in geometric progression with the clinical stage of the disease being 6, 12, 24, and 48 per cent for stages I, II, III, and IV, respectively.

4. Ureteral obstruction was present initially in half, appeared in the first year in a quarter, and later in a quarter of the cases, whereas bladder involvement was present initially in two-thirds, appeared in the first year in a quarter, and later in the remainder of the cases.

5. Frequent involvement of other structures by carcinoma was seen. A tragic triad of ureteral obstruction, femoral nerve root pain, and leg swelling was often present.

6. Three year survival rates were profoundly influenced by urinary tract involvement, being reduced in stage I from 73 to 30 per cent, in stage II from 53 to 11 per cent, in stage III from 29 to 12 per cent, whereas in stage IV remaining at 7 per cent. The survival rate for the entire group was reduced from 50 to 13 per cent.

7. Three year survival for patients with involvement of ureters was 20 per cent, of bladder 10 per cent, and of both bladder and ureter 5 per cent. All 20 of the vesicovaginal fistulas in this series were malignant, and the patients were dead at 2 years.

8. Surgical relief of obstructed ureters in 20 cases resulted in no longer survival than expectant management in 77 cases.

9. Few serious urinary tract complications could be ascribed to the radiotherapy in this series.

10. Although urinary tract involvement is common in women who die of carcinoma of the cervix, this may not in itself be the cause of death but merely an indication that the patient has a particularly invasive carcinoma of a lethal nature. The actual cause of death is obscure.

11. The surgical management of urinary tract complications of carcinoma of the cervix should be based on very careful evaluation of all the relevant factors in simultaneous consultation between the responsible radiotherapist, gynecologist, and urologist.

12. Attention has been focused on a group of patients with carcinoma of the cervix who are particularly difficult to treat by any means and who should be submitted to an even more intensive study of a biologic nature.

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THE PHYSICAL PROPERTIES OF ARTERIES AFTER ENDARTERECTOMY

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FUNCTION AND PATENCY of arteries are dependent in part on their physical characteristics. Since endarterectomy is performed on diseased vessels which then undergo definite anatomic changes in the healing process, it would seem that the physical properties of the arterial wall would also change. Barker and associates and I have both demonstrated that healing after endarterectomy takes place by collagen formation and eventual fibrosis in the area previously containing atheromatous intima and media. The present experiments were carried out in order to determine the degree of change in breaking strength and elasticity of the artery wall immediately after endarterectomy, in humans and dogs, and after healing of the artery wall, in dogs.

METHODS

Group I. Human iliac arteries. A standard endarterectomy was performed on 8 human atherosclerotic common iliac arteries obtained at postmortem examination. These preparations and intact adjacent diseased arteries were cut into cylindrical segments measuring exactly 0.5 centimeter in length by using a rigid cutting device. The segments were then submitted to tensile testing and elongation measurements with the Instron apparatus. This is an electronic weighing device employing strain gauges which records response of the given material to increasing loads applied to it. The cylindrical tube of artery is placed so that the spindles of two armatures hold it in position (Fig. 1). One armature moves downward from the fixed spindle of the other at a predetermined speed of 0.5 inch per minute. The elongation and response up to actual breaking of the specimen are recorded on a moving chart with a speed of 5 inches per minute. The breaking strength is recorded in grams necessary to disrupt the arterial cylinder, and elongation is recorded as centimeters of stretch prior to actual rupture. Elongation, as described in these studies, is actually lateral or radial stretching of the arterial cylinder since a load is applied on opposite inner walls of the specimen.

Group II. Experimental endarterectomy in canine aorta. Aortic intimectomy was carried out on 20 dogs through 2 longitudinal aortotomies 1.5 centimeters apart leaving a tunnel of denuded adventitia and media up to 5 centimeters in length. The aortotomy incisions were closed with interrupted mattress sutures of No. 5-0 silk and flow was reconstituted. The animals were sacrificed at intervals up to 6 months, namely 7, 14, 28, 42, and 180 days. Only patent aortic specimens were used for study. Similar tests with the Instron apparatus were then carried out on 0.5 centimeter cylinders of normal canine aorta for control and endarterectomized aorta with and without a suture line.

RESULTS

Group I. The breaking strength was maintained and, in fact, increased slightly when compared to adjacent intact segments (Fig. 2). The shape of the load-elongation curve was generally smoother after endarterectomy, probably because the sclerotic, partially calcified, intimal layer had been removed. Arterial elasticity as measured by

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Aided in part by a research grant, H-3345, from the National Heart Institute, National Institutes of Health, U. S. Public Health Service.

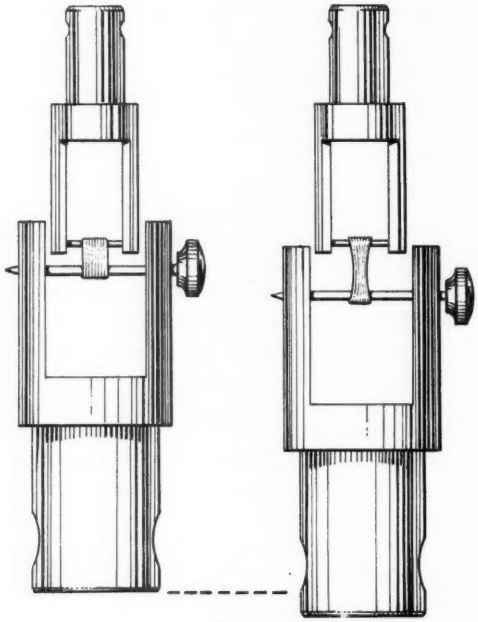

FIG. 1.

FIG. 1. a, left, Sketch of arterial cylinder being held by armatures prior to testing. b, right, Shape of specimen while lower armature applies force to it. This device is attached into Instron apparatus which records degree of response to gradually increasing loads.

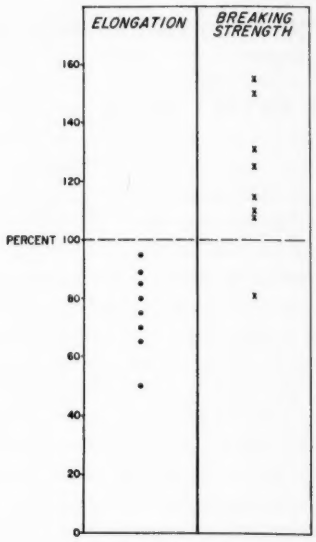

FIG. 2.

FIG. 2. Elongation and breaking strength of human —atheromatous—common iliac arteries immediately after endarterectomy, percentage of control.

elongation was decreased slightly immediately after endarterectomy. It was believed that the relative absence of elastic fibers in the remaining arterial tube must play some part in this decrease.

Group II. The breaking strength of canine aorta was diminished immediately but gradually increased above normal after 14 days (Fig. 3). This gradually lessened to approximate the strength of the control specimens at the termination of the study period. When segments of endarterectomized nonsutured aorta were studied for elongation, it was seen that load elongation curves became shorter in time; the implication was that elasticity rapidly diminished after 7 days (Fig. 4). This diminution reached a plateau after 14 days and varied from 61 to 68 per cent of elongation of the normal aorta. Aneurysm formation was obtained in the healing wall of canine aorta in 2 instances as false aneurysms at suture lines, presumably due to leakage through sutured vessel walls.

DISCUSSION

An inherent difficulty with this study is our inability to depict the nature of change in physical properties of human arteries after endarterectomy. The results of this study imply that there is a mild diminution in the degree of radial stretching or elongation of human arteries after endarterectomy. However, there was a definite, small increase in the breaking strength of each of the endarterectomized arteries immediately after the operative procedure. It was noted that each of the control specimens containing diseased intima broke at a much lower load than the arteries with atheromatous intima removed. This observation implies that the bulk of artery wall strength comes from the adventitial layers. This concept has been suggested by the previous similar stud-

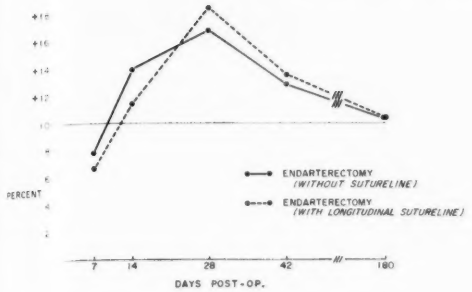

FIG. 3.

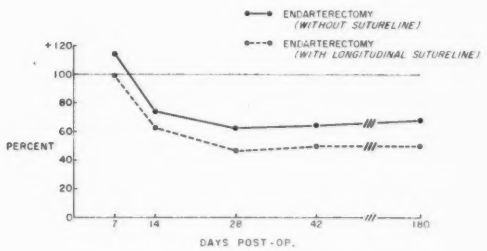

FIG. 4.

FIG. 3. Breaking strength of canine aorta after endarterectomy, percentage of control.
FIG. 4. Elongation of canine aorta after endarterectomy, percentage of control.

ies of Butcher and of Economou and associates.

It is, of course, difficult to transfer the results of animal experiments to human problems, but the healing process of the canine aorta is similar to that in the human after endarterectomy. The fibrous tissue which is laid down in the artery wall must be the major factor which determines the physical characteristics of a vessel after endarterectomy. It has been a common experience in secondary operations on arteries in which endarterectomy has been carried out to note the unyielding and leathery nature of the structure after many weeks. The relative increase in strength of the canine aorta after 14 days and the diminution in its elastic properties seem to be due to the new collagenized intima in addition to the striking fibrosis which takes place in the periarterial tissues.

It would appear that, after a properly performed endarterectomy by the semiclosed technique, fear of aneurysm formation or rupture is unwarranted. The distinct loss of elasticity, however, in time produces a relatively rigid tube, probably because of collagenization and fibrosis of the healing process. This loss of elasticity in a long vessel such as the superficial femoral artery may have a deleterious effect on its proper function and ultimate patency. The possibility of buckling is present, but this factor has not been demonstrated clinically as it has been with prosthetic tubes.

SUMMARY

The immediate effect of endarterectomy on human diseased iliac arterial segments was a minimal increase in breaking strength and decrease in demonstrable elongation as compared to adjacent atheromatous segments. In canine aorta this immediate effect was apparently reversed, but the long term observations of canine arteries after endarterectomy demonstrated a striking increase in breaking strength slowly approaching the control after 180 days and a marked diminution in elongation which reached a plateau shortly after 14 days.

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EDITORIALS

A PLEA FOR ACCURATE TERMINOLOGY IN GASTRIC SURGERY

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THREE operative descriptions entitled, "Subtotal Gastrectomy" have recently been reviewed.

The first report described the surgery in a middle-aged woman with an obviously benign chronic gastric ulcer in the midportion of the lesser curvature. Basal gastric analysis had revealed no free acid, although there was a moderate acid secretory response to histamine stimulation. The operation consisted essentially of an antrum resection. A considerable portion of the lesser curvature was resected in order to include the ulcer, but the major portion of the greater curvature of the stomach was preserved. Reconstruction was performed by the Shoemaker modification of the Billroth I operation—closure of the lesser curvature and end-to-end gastroduodenostomy.

The second note reported the operation upon a middle-aged male with chronic duodenal ulcer. Basal gastric analysis disclosed the characteristic hypersecretion. Operation consisted of a vagotomy and antrectomy. Certainly less than 40 per cent of the distal portion of the stomach was removed including approximately half of the lesser curvature. Reconstruction was achieved with the Hofmeister type of Billroth II gastrojejunostomy.

The third report represented a 62 year old female with carcinoma involving the body of the stomach. There was histamine achlorhydria, confirming the roentgenographic impression. Operation consisted in the en bloc removal of approximately 90 per cent of the stomach, 2 centimeters of duodenum, lesser omentum, greater omentum, spleen, and tail of pancreas. Reconstruction was by gastrojejunostomy with an ancillary jejunojejunostomy.

This same descriptive inaccuracy has been seen so often in recent years that I am convinced that many surgeons as well as surgical residents do not consider the semantics involved. No one questions the use of the term "subtotal thyroidectomy" for the operation usually performed for hyperthyroidism. No more than 5 to 10 per cent of the gland remains. In this context only the radical operation performed for potentially curable cancer of the stomach could qualify as a "subtotal gastrectomy." The mortality is in the range of 10 per cent, obviously unacceptably high for the treatment of a benign disorder such as peptic ulcer. Also the chronic morbidity has proved to be so great that nobody to my knowledge is presently performing a subtotal gastrectomy for peptic ulcer. In resection of the stomach for peptic ulcer, adjacent structures such as spleen and omentum can be, and usually are, preserved. It would seem to me more accurate to describe curative surgery for gastric cancer as "radical subtotal gastrectomy" in an attempt to describe the re-

gional rather than local nature of the resection.

In the last 15 years, benign gastric ulcer has become understood as a disease entity separate and distinct from duodenal ulcer. The differences in the sex ratio and the age incidence are well known. Even more striking, however, are the differences in the pathophysiology of the stomach and in the response to surgical therapy. The duodenal ulcer patient characteristically has hypersecretion of acid gastric juice in the basal state—in the absence of all apparent stimuli to gastric secretion. The stomach ordinarily shows prominent deep peristaltic contractions and rapid gastric emptying. In the gastric ulcer patient, on the other hand, the basal gastric secretion is actually less than in normal individuals, and there may be no free acid present at all unless a stimulant such as histamine is provided. Gastric motility is similarly depressed, and there is often retention of ingested materials.

The difference in the response of the two lesions to surgery may well be related to the difference in gastric secretion. Whereas the danger of marginal ulcer is perhaps the strongest single deterrent to surgery for duodenal ulcer, this complication is almost nonexistent after surgery for gastric ulcer. Experience has shown that it is not necessary to excise large amounts of the acid-secreting mucosa of the body of the stomach in gastric ulcer patients; a mere antrum resection is entirely adequate. This observation and other data support the hypothesis that the gastric antrum and its hormone gastrin are implicated in the genesis of gastric ulcer. Unlike gastric resection for duodenal ulcer, the Billroth I gastroduodenal reconstruction is entirely safe after antrectomy for gastric ulcer insofar as recurrence is concerned. The normal state of the duodenum in such patients is a technical advantage. The most apt descriptive title for such an operative procedure is "antrectomy" or "antrum resection."

There is a never ceasing hue and cry over inability to distinguish between a benign and malignant gastric ulcer as justification for radical surgery in ulcerated gastric lesions. This attitude is not justified by the facts currently at hand which indicate that this differentiation can be made with approximately 95 per cent accuracy. Roentgenographic examination alone will suffice in the majority of cases, and the "test of healing" on a medical regimen enhances this diagnosis. Exfoliative cytology has been used with a better than 90 per cent reliability. Gastroscopy has not proved to be of crucial benefit, although development of newer instruments is promising in this regard. In summary, the surgeon at the time of laparotomy can be reasonably certain of the nature of the lesion and, in most cases, can outline the proposed surgical procedure accordingly. The safety and certainty of conservative surgery for chronic benign gastric ulcer render it probable that this method of therapy is superior to medical treatment in most cases.

Surgery for duodenal ulcer differs in that, in all probability, the "target organ" rather than a primarily diseased structure is being attacked. When gastric resection alone is utilized this encompasses the pyloric antrum plus a moderate portion of the acid-secreting body of the stomach. The current practice in the hands of most surgeons using this procedure is to remove approximately two-thirds of the stomach with a modification of the Billroth II gastrojejunal reconstruction. Rather than "subtotal gastrectomy" this operation would more appropriately be entitled "distal partial (2/3) gastrectomy."

Several alternative operative procedures have been developed for the treatment of duodenal ulcer and are in wide use at this time. Each represents an attempt to overcome some of the drawbacks of the more extensive gastric resection. Segmental gastric resection removes a large share of the acid-secreting tissue while preserving the antrum and the normal gastroduodenal outlet. Vagotomy plus either pyloroplasty or gastroenterostomy attacks in essence only the exaggerated nervous phase of gastric secre-

tion while preserving the storage function of the stomach. A popular and effective combination is vagotomy plus gastric resection which removes both nervous and gastric hormonal phases of acid secretion. It is important to recognize that the gastrectomy portion of this procedure need encompass only the pyloric antrum and is in no sense a "subtotal gastrectomy." The antrum constitutes only the distal 20 per cent of the stomach but nearly half of the lesser curvature. This is sometimes referred to as "hemigastrectomy" but a more descriptive title is "vagotomy and antrectomy" or "vagotomy and antrum resection." Advocates of this combined procedure point to an exceedingly low ulcer recurrence rate as one of its major advantages.

Operative procedures involving the stomach can and should be varied in accordance with the principles involved in surgical treatment for gastric cancer, benign gastric ulcer, and duodenal ulcer. Titles given these operations should mirror this selectivity and should be adequately descriptive of the procedure(s) performed.

WHO SHOULD DO SURGERY OF THE HAND?

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APPROXIMATELY one-third of all injuries requiring the services of a physician or a surgeon, whether in the emergency department of a metropolitan hospital or the office of a rural practitioner, involve the hand. The physician administering the primary treatment for such injuries has a great responsibility, since his treatment determines, to a large extent, the final outcome.

All physicians must be taught the basic principles that should govern the treatment of an injury to the hand. They must know that it is important to protect wounds from contamination and infection and that adequate help, facilities, and proper instruments must be available before one starts to care for the injured hand. The traumatized hand must be cleansed thoroughly but gently. When compared with injuries of the arm, leg, or abdomen, the involved tissue of the hand should be sparingly debrided. Whereas many wounds of the arms and legs should be treated by delayed closure, almost all wounds of the hand should be closed primarily and this closure must be without tension. In some instances, the use of skin grafts is necessary to avoid tension. When possible, fractures should be reduced and immobilized at the time of the primary treatment. However, if the physician is not trained to care adequately for the bone injury, less harm will be done if the skin is closed, the hand is placed in a position of moderate dorsiflexion of the wrist, moderate flexion of the fingers, and moderate abduction and opposition of the thumb, and a bulky dressing is applied to prevent edema. In such selected instances, the fractures can be dealt with after the cutaneous wound has healed. Even more important is the necessity to realize that severed nerves and tendons do not require primary repair; less harm will be done under unfavorable conditions by secondary repair of nerves and tendons after the initial wound has healed. A surgeon who attempts primary suture of a flexor tendon in its digital sheath should have had considerable education, training, and experience in reconstructive surgical treatment of the hand and should be capable of performing a tendon graft.

Extensive reparative, restorative, reconstructive, and rehabilitative surgery of the hand should be carried out in hospitals by surgeons well qualified and dedicated to this field of surgery. The surgeon interested in treatment of the severely injured hand must be educated to work in orthopedic surgery, plastic surgery, and neurosurgery. He should have knowledge of dermatologic, circulatory, paralytic and arthritic diseases which are prone to affect the hand. He must be well versed in the most minute details of the surgical and functional anatomy of the entire upper extremity. He must be versed in rehabilitative procedures and trained in splinting and bracing. He must be capable of teaching the patient how to prevent and overcome stiffness of joints and how to co-ordinate muscles which formerly had one function but after a tendon transfer have another function.

Above all, the surgeon who devotes much of his time to surgery of the hand must teach medical students, interns, and residents how to care properly for injuries which affect the hand. Many of the principles established by such pioneers as Allen Kanavel, Sterling Bunnell, and Sumner Koch are still basic and pertinent. It is important that these principles be learned if crippling of the hand is to be minimized.

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EXPERIMENTAL APPRAISAL OF A NEW ANGIOGRAPHIC CONTRAST MEDIUM

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THE ADVANCES in cardiovascular surgery during the past decade have been accompanied by an increasing interest in and a wider application of contrast angiography in the diagnosis of cardiovascular lesions. During this era, many reports of adverse reactions to contrast angiography have appeared in the literature. Previous reports from this laboratory (2, 3) have clearly indicated that of the currently employed aortographic contrast media 90 per cent hypaque-M (1:2 mixture of sodium and N-methylglucamine diatrizoate) is the least toxic and that 70 per cent urokon (sodium acetrizoate) is the most toxic.

Recently, ditriokon, a new angiographic contrast agent containing a 37 per cent solution of sodium diatrizoate and a 31 per cent solution of sodium diprotrizoate has become available. Ditriokon has been tested and compared with the other angiographic contrast media as regards neurotoxicity, nephrotoxicity, viscosity, iodine content, and injection characteristics.

METHOD

A standardized method of testing animal tolerance to angiographic contrast media has been described previously (2, 3) but will be summarized briefly herein. Unselected mongrel dogs weighing 8.5 to 14.5 kilograms were anesthetized with 30 milligrams per kilogram of intravenous pentobarbital sodium, and with sterile operative technique the abdominal aorta was exposed through a midline abdominal incision. The tip of a No. 18 gauge needle was slanted cephalad after puncture of the anterior wall of the aorta 1 centimeter below the origin of the left renal artery, and 15 cubic centimeters of contrast medium were injected manually over 5 seconds.

The neurotoxicity of the agent was measured in terms of the immediate and postanesthetic neurologic responses of the animal. The immediate response consisted of a hindlimb motor reaction—hyperextension, hyperreflexia, or seizure—and the postanesthetic assessment of injury was based upon serial neurologic examination of hindlimb motor function during the postinjection survival period.

The nephrotoxicity of the agent was assessed by comparison of serial postinjection serum nonprotein nitrogen values to the preinjection control values. Surviving animals were sacrificed 1 week after injection, and histologic studies were made of the kidneys.

The viscosity of ditriokon was determined by a gravity pipette evacuation method. The contrast medium was room temperature, 22 to 23 degrees C, at the time of testing, and the results were expressed in terms of water as unity. The viscosity of various concentrations down to a 50 per cent solution of ditriokon was also determined. The medium was diluted with water in order to obtain the lesser concentrations. The viscosity measurements were utilized to determine the efficiency of iodine delivery in milligrams per second for each concentration of the contrast medium.

RESULTS

The neurologic responses to abdominal aortic injection of 15 cubic centimeters of ditriokon are

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recorded in Table I. Seven of the 14 animals injected manifested an immediate neurologic reaction to the injected contrast medium. These reactions of the hindlimbs consisted of hyperextension and/or hyperreflexia which appeared approximately 1 minute after injection and lasted from 1 to 5 minutes. There was no instance of hindlimb seizure. Upon recovery from anesthesia, in 2 animals there was unilateral hindlimb weakness, 1 animal had motor weakness of both hindlimbs, 1 had paralysis of 1 hindlimb, and 1 had paralysis of both hindlimbs. Thus, 5 animals exhibited evidence of spinal cord injury severe enough to produce some loss of motor function. The incidence of neurologic injury was not related to the weight of the animals (Table I). In each instance, the neurologic deficit decreased over the ensuing week. After 1 week, the animals which originally displayed paresis were completely normal neurologically, and those which originally showed paralysis had only a mild residual paresis.

The serial serum nonprotein nitrogen values uniformly remained within normal limits. All animals survived to the time of sacrifice, 1 week after the test injection. At necropsy, no gross renal damage could be detected. Microscopic examination of renal tissue obtained at necropsy revealed no abnormality in 12 animals, and in the remaining 2 animals there were proteinaceous casts and cellular debris within the lumina of the renal tubules. The glomeruli revealed no significant abnormality. The changes noted in the renal tubules were the result of recent tubular necrosis (Table I, Fig. 1).

The viscosity of 68 per cent ditriokon is 1.4 compared to water as unity. Viscosity studies of lesser concentrations of ditriokon reveal the undiluted solution to be the most efficient for vascular opacification (Fig. 2).

TABLE I.—NEUROLOGIC AND RENAL RESPONSE TO AORTIC INJECTION OF 15 CUBIC CENTIMETERS OF DITRIOKON

		Neurologic response		Renal response	
Dog No.	*Weight, kgm.*	*Anesthesia period*	*Post-anesthesia*	*Azotemia*	*Nephropathy*
56-D	12.0	○	○	○	○
57-D	10.5	○	○	○	○
881-D	9.5	+	⊕	○	○
950-D	11.0	+	◈	○	○
108-E	8.5	○	○	○	○
109-E	9.0	○	○	○	○
127-E	13.0	+	◆	○	○
128-E	14.5	○	○	○	○
130-E	10.0	+	○	○	○
131-E	9.5	+	○	○	Yes
147-E	11.0	○	○	○	○
148-E	13.0	+	⊕	○	Yes
150-E	12.5	+	⊕	○	○
151-E	13.3	○	○	○	○

○ = No abnormality.
\+ = Hyperextension or hyperreflexia.
⊕ = Paresis.
◆ = Paraplegia.
◈ = Unilateral paralysis.

TABLE II.—INCIDENCE OF NEUROLOGIC AND RENAL RESPONSE TO AORTIC INJECTION OF 15 CUBIC CENTIMETERS OF CONTRAST MEDIA

Contrast medium	*No. of animals*	*Hyperirritability motor responses, per cent*	*Paresis, per cent*	*Paralysis, per cent*	*Azotemia, per cent*
70 per cent urokon	10	100	0	100	100
90 per cent hypaque-M	30	43	7	0	0
68 per cent ditriokon	14	50	21	14	0

TABLE III.—CRITICAL ANGIOGRAPHIC PROPERTIES OF THE ORGANIC IODIDE CONTRAST MEDIA

Agent	*Concentration, per cent solution*	*Iodine content, mgm./c.c.*	*Viscosity**
Urokon	70	461	1.3
Hypaque-M	90	462	4.5
Ditriokon	68	400	1.4

*Compared to water at room temperature as unity.

DISCUSSION

The results of previous studies assessing the toxicity of 70 per cent urokon and 90 per cent hypaque-M are summarized and compared in Table II with the toxicity data obtained under exactly the same conditions in the present study on ditriokon. When submitted to the standard test, 70 per cent urokon routinely causes spinal cord injury which results in permanent paraplegia and renal damage causing tubular necrosis which results in azotemia. Under the same test circumstances, 90 per cent hypaque-M does not cause detectable renal injury. Although it rather often elicited an immediate neurologic reaction of the hindlimb, only rarely did hypaque cause spinal cord injury sufficient to produce a postanesthetic motor deficit. In no instance was there complete motor paralysis of the hindlimbs after injection of hypaque. Seventy-five per cent neo-iopax, 70 per cent diodrast and 90 per cent miokon have toxicities intermediate between those of 70 per cent urokon and 90 per cent hypaque-M. Ditriokon possesses neurotoxicity and nephrotoxicity characteristics much more nearly those of 90 per cent hypaque-M than those of 70 per cent urokon, 75 per cent neo-iopax, 70 per cent diodrast, and 90 per cent miokon; how-

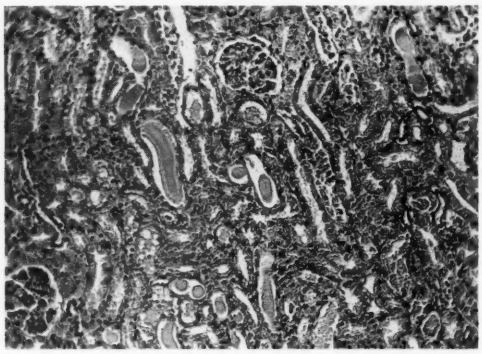

FIG. 1. Photomicrograph of kidney from dog 148-D obtained 7 days after aortic injection of ditriokon. Note protein debris and casts within the tubular lumina as well as the vacuolization and breakdown of the tubular epithelium. The glomeruli and vessels appear to be intact. ×47.

ever, ditriokon is clearly more neurotoxic than 90 per cent hypaque-M (Tables I and II).

Clinical experiences with 90 per cent hypaque-M and 70 per cent urokon have also emphasized the toxicity of urokon and the blandness of hypaque. Analysis of a collected series of 43 instances (1) of spinal cord injury incident to aortography reveals that urokon was the contrast medium used in 87 per cent of the cases. The incidence of renal damage secondary to aortography using urokon has also been significant. Thus far, the clinical experience with hypaque has been more favorable with regard to toxic reactions as reported by McAfee. At the present time, we are unable to find reports of clinical experiences with the use of ditriokon.

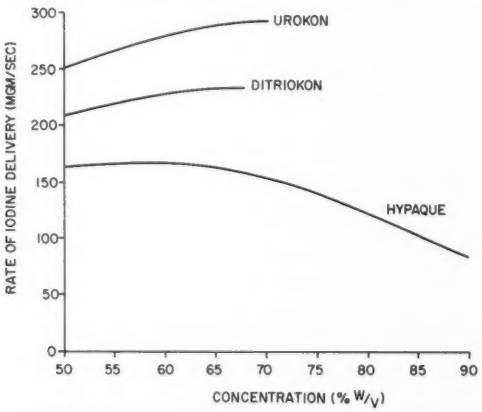

FIG. 2. Relative rates of iodine delivery for the various concentrations of the contrast media using a standard delivery technique. Urokon and ditriokon have maximum efficiency for opacification in the undiluted state, whereas, the optimal concentration for hypaque ranges from 50 to 65 per cent.

The relative neurotoxicity and nephrotoxicity of ditriokon as determined in this study are as might be anticipated from the study of the toxicities of its constituents. The diatrizoate salt of ditriokon is identical to sodium diatrizoate of hypaque. The sodium diprotrizoate of ditriokon is also common to miokon (2:1 mixture of N-methylglucamine and sodium diprotrizoate). Ninety per cent miokon and 90 per cent hypaque-M possess minimal nephrotoxicities, but miokon is toxic to the central nervous tissues. The nephrotoxicity of ditriokon appears to be of the same order as those of 90 per cent hypaque-M and 90 per cent miokon, but the neurotoxicity of ditriokon is intermediate between those of hypaque and miokon.

The test employed in this study to evaluate neurotoxicity and nephrotoxicity is admittedly a severe one. The quantity of contrast medium utilized clearly exceeds the relative amounts usually used clinically. However, this standard test procedure serves to magnify the relative toxicities of the contrast media and allows clearer definition of the medium possessing the greatest margin of safety.

Table III contains the results of the comparative studies of the iodine content and viscosity of 68 per cent ditriokon, 90 per cent hypaque-M, and 70 per cent urokon. Ninety per cent hypaque-M is roughly 3.5 times as viscous as the other 2 contrast media at 22 degrees C. Figure 2 shows the relative rates of iodine delivery for various concentrations of the 3 contrast media when constant conditions of injection are used. Similar curves for neo-iopax, diodrast, and miokon have been noted to fall below that of ditriokon (4). Ditriokon and urokon reach maximal delivery values in the undiluted state. The disadvantage of the viscous nature of 90 per cent hypaque-M is reflected in the fact that if it is diluted to a 50 to 60 per cent solution, the maximum iodine delivery rate is obtainable.

The low viscosity of ditriokon makes it second only to 70 per cent urokon in the efficiency of the organic iodide angiographic contrast media for producing radiopacity. The viscosities of 70 per cent urokon and 68 per cent ditriokon are much less than that of 90 per cent hypaque-M.

The presence of N-methylglucamine diatrizoate in hypaque-M and the greater concentration of 90 per cent hypaque-M are responsible for its marked viscosity. The extreme viscosity of 90 per cent hypaque-M creates difficulties in the handling and injection technique. These difficulties, however, are not insurmountable. If 90 per cent hypaque-M is heated to approximately 40 degrees C. the viscosity is diminished significantly. In this state 90 per cent hypaque-M can be readily injected and excellent aortograms result. Once heated, 90 per cent hypaque-M remains in solution at room temperature for several days.

SUMMARY AND CONCLUSIONS

Experimental testing of a new contrast medium, ditriokon, reveals it to be more efficient for vascular opacification than any other angiographic contrast agent except urokon. Ditriokon is less toxic than any other contrast agent except hypaque. Ninety per cent hypaque-M is proved to be a safe and adequate contrast medium for aortography and angiocardiography, and 50 per cent sodium hypaque provides similar characteristics for arteriography. Ditriokon is more neurotoxic than 90 per cent hypaque-M. Perhaps this difference in neurotoxicity would not be clinically significant; however, until safer media of equal or greater radiopacity are developed 90 per cent hypaque-M and 50 per cent sodium hypaque remain the contrast media of choice.

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AN IMPROVED TROCAR FOR ASEPTIC DECOMPRESSION OF OBSTRUCTED SMALL BOWEL

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Brooklyn, New York

ASEPTIC DECOMPRESSION of markedly dilated bowel is a vital step in the proper management of mechanical obstruction of the small bowel. Such decompression obviates serosal or complete tears of the thin, edematous wall, permits complete abdominal exploration in relative safety, and makes for greater ease in dealing with the cause of obstruction and with the often difficult abdominal closure. It is our impression too that markedly dilated bowel assumes normal peristaltic activity more rapidly in the postoperative period if it has been decompressed at the time of laparotomy. For the past decade aseptic operative decompression of moderately or markedly dilated bowel has been a nearly routine practice on our service in the management of patients with obstruction of the small bowel. Prior to 1955 an empyema trocar was used in the fashion described by Wangensteen in his classic treatise on obstructions. We found this method not entirely satisfactory, for the available trocars would accommodate only catheters of narrow caliber, the maximum being No. 14 F. These narrow catheters nearly regularly became plugged with the solid materials being aspirated and very often led to unsatisfactory decompression. For this reason we devised a trocar that would accommodate a large catheter and in addition would lend itself to an aseptic decompression of the bowel.

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The trocar consists of inner and outer steel tubes (Figs. 1 and 2). The inner tube is longer and on one end is beveled and sharpened. At the opposite end of the inner tube is a series of 7 circumferential ridges about 2 millimeters in height and width. Near this end is a solid side arm which moves along a slot in the outer tube. By moving this side arm into short extensions of the slot the inner tube can be locked in position with its sharpened end either protruding or withdrawn. A No. 30 F. rectal tube passes freely through this inner tube. The outer tube fits very snugly about the inner tube but it is shorter and has on one end a ridge of metal and a wide metal flange. In addition to the trocar and the rectal tube, a large Penrose drain and sterile mineral oil are needed to perform the decompression aseptically.

PROCEDURE

The component parts are sterilized by autoclaving. They are assembled at the operating table, preferably prior to the laparotomy. The rectal tube is lubricated with mineral oil and attached to suction tubing. It is then passed through the Penrose drain and through most of the trocar. The Penrose drain is then tied securely to the inner tube of the trocar, at the

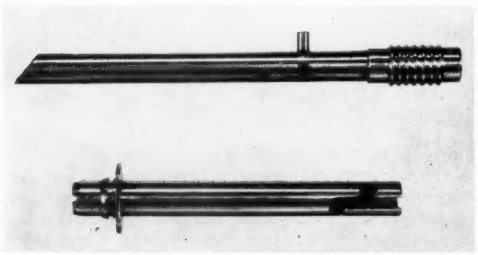


FIG. 1.

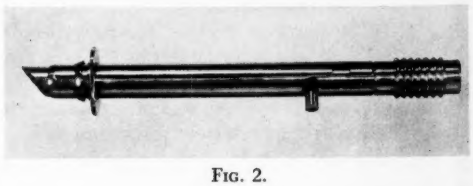


FIG. 2.

FIG. 1. Above, Inner cannula; below, outer cannula.
FIG. 2. Trocar assembled with cutting edge of inner cannula protruding.

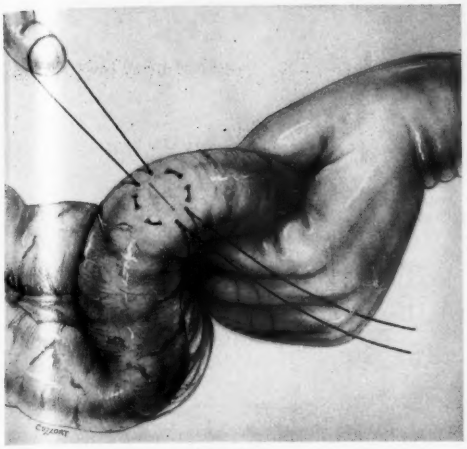


FIG. 3.

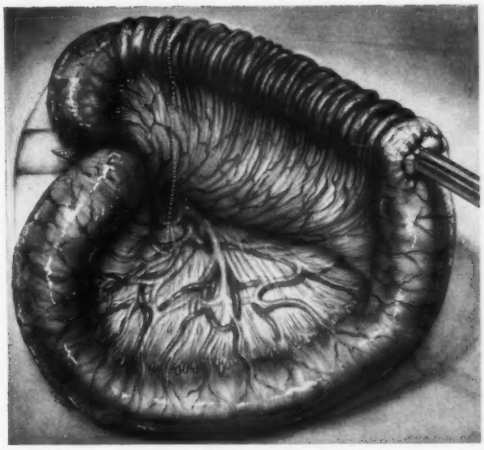


FIG. 5.

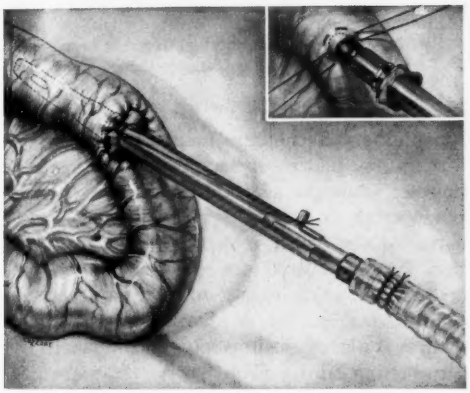


FIG. 4.

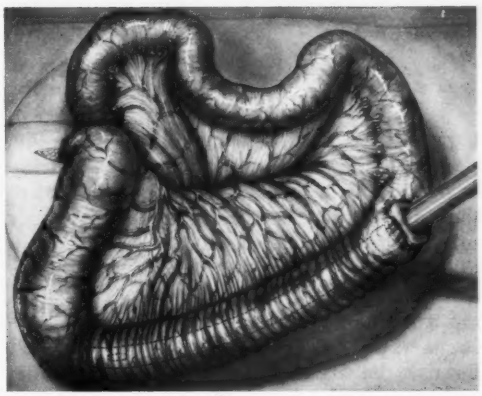


FIG. 6.

FIG. 3. Placement of purse-string suture with location of seromuscular incision shown in dotted lines.

FIG. 4. Inset, Trocar being inserted into intestinal lumen. Larger drawing shows trocar inserted, purse-string suture tied, and tied again to side arm of inner cannula. Note that inner cannula is in the withdrawn position, so that cutting edge no longer protrudes.

FIG. 5. Bowel reefed on fully inserted rectal tube.

FIG. 6. Trocar and rectal tube redirected into distended segment. Note the collapsed bowel which has been decompressed.

series of ridges, and also to the suction tubing just distal to where the rectal tube is attached. These ties must be sufficiently secure to be watertight.

As soon as the abdomen has been entered the first loop of distended bowel encountered is chosen for the site of decompression. Only this loop of bowel is exteriorized and no exploration of the peritoneal cavity is carried out at this time. A purse-string suture of No. 000 silk is placed in the distended loop, and a small transverse incision—through the seromuscular layers only—is made within the circle described by the purse-string suture (Fig. 3). With the purse-string ends held snugly, the trocar, with the cutting edge of the inner tube protruding, is forced rapidly through the incision and into the lumen of the bowel. It is important that suction be applied and maintained during the introduction of the trocar. The purse-string suture is

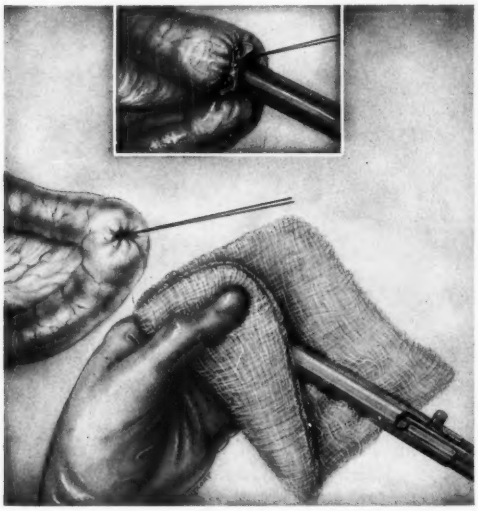


FIG. 7.

FIG. 7. Purse-string suture tied and trocar withdrawn. Inset shows where purse-string suture had been tied around the trocar in the space between the ridge and the flange.

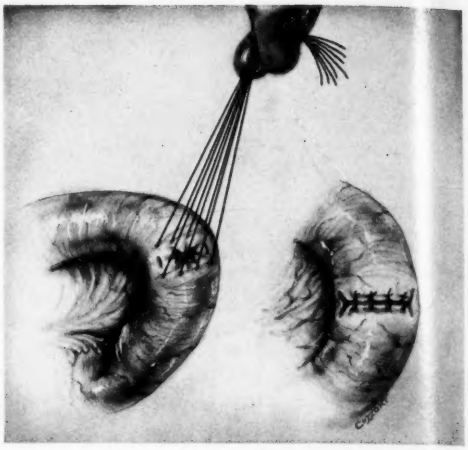


FIG. 8.

FIG. 8. The row of Lembert sutures has been placed and tied. In this particular instance the purse-string suture was left in situ.

partially tied around the trocar between the ridge and the flange, only the original double throw of a surgeon's knot, and then secured to the side arm of the inner tube after the inner tube has been partially withdrawn and locked in the noncutting position (Fig. 4). This latter maneuver prevents the inadvertent extrusion of the trocar during the manipulations of the decompression. The rectal tube is then introduced through the trocar and well into the intestine, and suction is applied. After the presenting loop is decompressed, the bowel is gently reefed on the tube, and often many loops can be decompressed (Fig. 5). When all the bowel in this direction, proximal or distal, is decompressed the rectal tube is partially withdrawn, the trocar is redirected in the opposite direction, the rectal tube is reinserted, and as many remaining loops as possible are decompressed (Fig. 6).

After decompression has been achieved, the purse-string suture is cut from the side arm of the inner tube. The surgeon then takes a large dry laparotomy pad in one hand and the trocar in another while the assistant takes the ends of the purse-string suture and applies slight tension to each. As the trocar is rapidly withdrawn, suction being maintained throughout this procedure, the purse-string suture is snugged and then tied (Fig. 7). A short row of Lembert sutures is placed transversely, encompassing the purse-string suture (Fig. 8). As these are tied, the purse-string suture can be cut and removed or left in place; we have done it both ways and see no advantage in either. There has been no obstruction at the site of a purse-string suture that was left in place. The surgeon next directs his attention to determining the cause of the obstruction and dealing properly with it.

This method of decompression has been used by us and by a number of our resident surgeons on more than 70 occasions. It has always given an eminently satisfactory result.

Field Marshal Erwin Rommel
1891 – 1944

The Book Shelf

ON A ROAD IN NORMANDY—17 JULY 1944

RICHARD A. DAVIS, M.D., Philadelphia, Pennsylvania

A brave man struggling in the storms of fate,
And greatly falling, with a falling state.
ALEXANDER POPE

IF HISTORY gives, at best, a brief glimpse into past realities and teaches lessons for the future, one might ask if a series of events which transpired on a picturesque road in the *bocage* country of Normandy in any way changed the subsequent course of World War II and the trend of Western European history for some years to follow. The third week of July 1944 was not only a critical one from the military standpoint, but if the Allied High Command could have "looked on the other side of the hill" and been fully aware of the German Generals' Revolt and the attempted assassination of Adolf Hitler, then the near-fatal injury of Field Marshal Erwin Rommel becomes almost a classical act of tragic fate. Did the skull fracture sustained by Rommel several days before the Hitler bomb plot have a bearing on the eventual termination of the War? Who was the man behind the Rommel legend? Had the circumstances been right, could this soldier of conservative background and unquestionable military genius have summoned the needed intellectual boldness and imaginative spirit to lead the professional German Army against the most feared and unscrupulous tyrant of modern times? And lastly, one might question, are all men and their leaders fundamentally carried along by the tide of history?

This, then, is the story of 17 July 1944 and a reconstruction of Rommel's movements, the accident, his medical care, recovery, and a reference to the aftermath. But the background leading to this day and its events began years before.

Erwin Johannes Eugen Rommel was born in November 1891, at Heidenheim/Brenz in Württemberg, one of five children. His father was a schoolmaster and mathematician. As a youngster, Rommel was characterized as quiet and shy but later became interested in skiing and all types of outdoor activities; he developed into a good student and had the ambition to be an engineer but later chose the Army. There was no family military tradition, and he did not have a select schooling. In July 1910, Erwin Rommel joined the 124th Infantry Regiment as an officer-cadet and remained a professional soldier until his death some 34 years later. After he was commissioned a Lieutenant in January of 1912, he married Maria Lucia Mollin; today his widow, son, and daughter-in-law live in Stuttgart.[1] In 1914 Rommel fought against the French on the Western Front and then was sent to Romania and Italy with the Alpenkorps. He was awarded the Pour le Mérite for a remarkably bold operation at Monte Matajur against the

From the Department of Neurological Surgery, School of Medicine University of Pennsylvania, Philadelphia.

FRONTISPIECE: Permission for reproduction of the colored photograph of Field Marshal Rommel which first appeared in *Schicksal Nordafrika* has been given by: Europa-Contact-Gesellschaft für Intereuropäische Beziehungen MBH, Stuttgart, West Germany.

[1]Both Frau Rommel and her son Manfred have read this manuscript and made important corrections and additions. They have generously permitted material concerning the Field Marshal's accident in Normandy to be published. I am most grateful to them for their kindness and hospitality while at Stuttgart in 1957.

Italians, a combat decoration the counterpart of the United States Congressional Medal of Honor and British Victoria Cross.

During the years of unrest in the twenties and the depression, Rommel remained in the regular German Army (Reichswehr) and work was his sole interest and preoccupation. His record showed that he was tough and aggressive in combat, was an outstanding leader, and being popular with his contemporaries was of little concern to him. In 1929 he was stationed at the Infantry School in Dresden, and a series of lectures delivered during the next 4 years culminated in a well written text, *Infanterie Greift An* (Infantry Attacks), which was illustrated by the author. Major Rommel commanded the 3rd Battalion of the 17th Infantry Regiment in October of 1933; this was a Jaeger or mountain battalion, and all ranks were expert skiers, including the commanding officer. In 1935 he was assigned as an instructor at the War Academy in Potsdam and, when promoted to Lieutenant Colonel, was given the opportunity of taking examinations for the Staff College which would have made him eligible for the High Command. He preferred to remain with the troops.

While at Potsdam, Rommel was posted temporarily to the so-called Fuehrerbegleitbattalion, or formation entrusted with Hitler's personal safety during the annexation of the Sudetenland in 1938. For the first time, Rommel was in close contact with Hitler and the "center of things" during one of Europe's gravest crises. Rommel had been trained in the tradition of the Reichswehr which forbade the Army to participate in politics or to vote and demanded a rigid loyalty and obedience, probably not fully understood by the more democratic western societies. It is little wonder that he was not particularly interested or concerned with political matters.

Rommel was a Colonel in the autumn of 1938 and commanded the War Academy at Wiener Neustadt. One year later he was assigned to Hitler's military headquarters and was promoted to Major General. After the 4 week campaign in September 1939 when Poland was quickly defeated, Rommel chose the proper occasion to ask Hitler for an armored unit. On 15 February 1940, he reported as the commanding officer of the 7th Panzer Division. The Battle of France was launched on 10 May 1940; Rommel's division crossed the Meuse near Dinant and then attacked across the flat plains of France through Le Cateau, Cambrai, Arras, Lille, and then to the Channel. The operation reports of the 7th Panzer Division showed that Rommel insisted on command from a lead tank position, and, as a result of his several narrow escapes with death or capture, one realizes that he was a leader who never asked anything of his troops which he had not done himself. After the French surrender, Rommel remained with his division in garrison duty for 6 months and later wrote his wife:

> 7 February 1941—Slept on my new job last night. (It is one way of getting my rheumatism treatment.) I've got a terrible lot to do, in the few hours that remain, getting together all that I need (1).

As a result of General Archibald Wavell's offensive in December 1940, the Italian position in North Africa had become so critical that the Germans sent two divisions, 5th Light and 15th Panzer, to undertake the defense of Tripolitania. This rather inauspicious arrival was recorded by the British High Command, "Detachments of a German expeditionary force under an obscure general, Rommel, have landed in North Africa" (5). But Rommel was undaunted by the situation which he had inherited, and at once the newly initiated Afrika Korps struck across the Western Desert and by June 1941 had driven the enemy back to the Egyptian frontier. The early successes of Rommel and his "Africans" rapidly made him the most celebrated and heralded German field commander, and it was indicative of his alertness, professional skill, and a sense of almost medieval chivalry that prompted the British to refer with no little admiration to "Our friend Rommel" and "The Desert Fox."

In the closing months of 1941, after an unsuccessful siege of Tobruk, the Afrika Korps was attacked by a reinforced enemy, and the British 8th Army proceeded to drive them back to the starting point of the campaign. However, the seesaw conflict continued, and early in 1942, when his destruction had been prematurely announced, Rommel launched his famous counterstroke which carried the success of German military effort in the Western Desert to its zenith. On 27 May 1942 the offensive which led to the capture of Tobruk was commenced, and the British were pursued relentlessly to an obscure rail point in Egypt, El Alamein. None was more aggressive and determined for victory than Rommel and the Afrika Korps; it has been

said over and again that they asked for no quarter and gave none. However, this battle in the vast spaces of desert was fought by a set of rules; the wounded and prisoners were invariably treated according to the Articles of the Geneva Convention. Professor Ian Aird, who was with the 4th Indian Division attached to the 8th Army, has been kind enough to relate this story about Field Marshal Rommel illustrative of his concern for his men.[2]

In November of 1941, the Afrika Korps was pressing hard for the capture of Tobruk along the Mediterranean coast which contained vast supplies of munitions, food, and gasoline. The battle was a fast moving one with a series of tank engagements at Gazala, Sidi Rezegh, and Knightsbridge.

On 24 November 1941 near Sidi Omar, Major Aird and his hospital unit were overrun by the Germans and were prisoners for the next 36 hours. During the night of 24 November, Major Aird performed a number of operations, including the exploration of a dozen perforating abdominal wounds on Indians and Italians; he was attached at the time to the 4th Indian Division. His diary states that in the forenoon of 25 November, Colonel Fritz Rudolf Stephan, the brilliant commander of the 5th Regiment, 15th Panzer Division, was brought to the operating tent, a lean-to behind a three ton truck, with a large sucking wound of the chest. He had been hit by shrapnel and the hilus of the right lung was damaged, but bleeding had been lessened by the application of shell dressing. He was severely shocked, but his medical officer, unaware of the immediate availability of elaborate surgery, asked merely that an additional pressure dressing be applied so that Colonel Stephan could be flown back to base. Major Aird considered however that his shock required immediate treatment; and when the German doctor saw a transfusion begun and the quite elaborate surgical equipment of the operating tent, he left it to consult with Field Marshal Rommel who was standing outside the tent with a column of armor. Returning to the tent, he authorized Major Aird to operate. The armored column meanwhile was attracting the fire of British batteries, and Major Aird's anesthetist, Captain Bamford, pointed out that the shell fire was disturbing to the wounded. Again the German doctor left the operating tent, and Rommel ordered his column to move away a short distance.

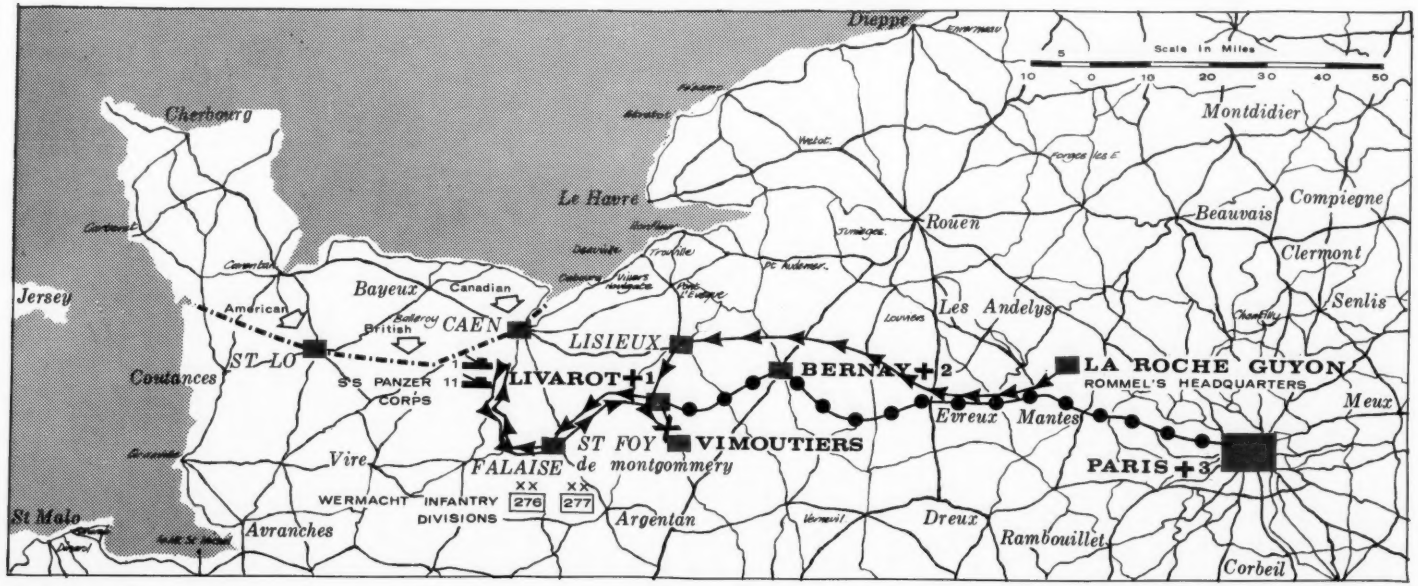
The operation was begun and Field Marshal Rommel with ten or twelve members of his staff came into the operating tent to watch. Before the operation was completed, British shellfire became extremely heavy, and the German column withdrew about a mile westward; the German doctor had explained to Aird that they would return next day on their way into Egypt. Unfortunately, damage to the lung was irreparable and Colonel Stephan died from what was virtually a severance of the right lung from the heart.

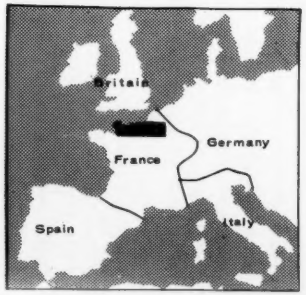
He was given a Protestant funeral and the particular frontier post beside which his grave lay on the Libya-Egypt border was accurately recorded. Colonel Stephan's heroic behavior during his last conscious minutes made such a lasting impression on Major (now Professor) Aird that, with the help of the British Foreign Office, he made contact with Colonel Stephan's wife after the War and recounted to her in detail the events which attended her husband's death.

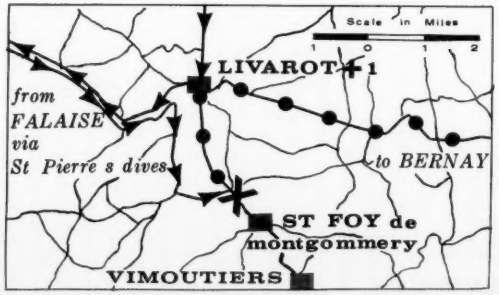
Following the German and Italian defeat in North Africa, Rommel was sent to northern Italy for recuperation. In the fall of 1943 he was made inspector of Coastal Defenses of the Atlantic Wall, and during the next 6 months worked at top efficiency to improve and strengthen all obstacles which would prevent enemy sea and glider landings. Rommel was made commander of Army Group B prior to the Allied landings and believed that the weight of the Army should be shifted forward to the coast so as to destroy the enemy on the beaches. From the North African campaign he had learned that the terrain of Normandy was not suited for mobile warfare.

Meanwhile, important changes had occurred in Rommel's outlook and thinking. Prior to the War and during the years of German victories, Hitler had been his patron and loyal supporter, but his blind refusal to evacuate the Afrika Korps and inflexible position in all military problems convinced Rommel that all avenues of reason were closed. Rommel also was approached by his old friend, Karl Strölin, and became aware of a conspiracy to capture Hitler and oust the Nazi Party; following this, peace

[2]Professor Ian Aird, Department of Surgery, Postgraduate School of Medicine, London University, has explained the trying circumstances and great difficulties encountered in caring for the wounded during the Western Desert campaign. He has generously written the episode of his meeting with Field Marshal Rommel in 1941 near Sidi Omar.







MOVEMENTS

Relative to the Accident

17 JULY 1944

Battle Line
Journey before the Accident
Journey after the Accident
Hospitals
1 ASILE
2 LUFTWAFFE
3 ST GERMAIN
VESINET

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overtures would be made to the Allies. He knew of the military indiscretions taken by the SS and the crimes perpetrated by the Gestapo; in short, he had become disillusioned in Germany's cause and realized that military victory was no longer possible. In the closing days of 1943 and prior to the Normandy Invasion, Rommel developed a political point of view and philosophy for the first time in his life. It became of primary importance to him that Germany should not be destroyed and sacrificed in a battle which all military calculation indicated was already lost.

As the anti-Hitler movement grew, resistance began to take solid form, and many of Germany's ranking soldiers were aware of the plans which had been formulated by Generals Ludwig Beck and Erwin von Witzleben as well as Dr. Goerdeler, the Mayor of Leipzig. Witzleben had been designated as the Commander-in-Chief of the German Army if the plot against Hitler succeeded. In the West, the center of the conspiracy was General Karl Heinrich von Stuelpnagel, the military Governor of France; Graf Schenck von Stauffenberg, Lieutenant Colonel Caesar von Hofacker, and Colonel Hans Otfried Linstow were also deeply committed. General Hans Speidel, the Chief-of-Staff of Army Group B, and General Freiherr Hans von Boineburg were aware of the conspiracy and firmly believed that Rommel should lead the Army against the SS and other military formations of Hitler and Himmler (6).

The successful Allied landings and severe losses which the Wehrmacht suffered during June and July further convinced Rommel that his course was correct, and now the conspirators were ready to act. On 15 July 1944 Rommel advised Hitler that the situation in France was desperate and the front could hold only a matter of days before a major breakthrough occurred; it was his final warning to Hitler and the High Command. The story of the 20 July attempt on Hitler in East Prussia is well known, and the explosion left him injured, but alive; all persons even remotely suspected of participation were executed. The group in Paris captured the SS barracks and Gestapo headquarters but, when they learned Hitler was alive, released their captives; they paid heavily for their mistakes. At this critical time when the future of so many hung in the balance, where was Rommel and what fate had overtaken him?

FIG. 1. The location on the main road from Livarot to Vimoutiers near Ste. Foy where Field Marshal Rommel's command car was strafed by Allied aircraft on 17 July 1944.

Monday, 17 July 1944 was a clear, hot, and rather humid summer day in Normandy, and at approximately 6:00 a.m. a command car, an eight-cylinder Horch, left German Army Group B headquarters at La Roche Guyon with Field Marshal Erwin Rommel, his aide Captain Helmuth Lang, Major Neuhaus, Sergeant Holke, and their driver, Sergeant Daniel. They drove directly west through Évreux, Lisieux, and Livarot; after a 6 hour journey they reached the command post of the 277th Infantry Division, where a conference was held. A similar visit was made to the headquarters of the 276th Division, which was deployed near Falaise. These two divisions had been under heavy enemy attack during the preceding day and night, and Rommel learned that their reserves were depleted. He then drove to the headquarters of the 1st and 2nd SS Panzer Korps and discussed the front line situation with Major General Willi Bittrich and Lieutenant General Josef Dietrich. On 17 July 1944 the battle line extended from the mouth of the Orne River on the east, through Caen, Caumont, St. Lô, and Lessay in the west.

About 4:00 p.m. Rommel and his staff left the command post of General Dietrich for the return trip to La Roche Guyon. He was anxious to reach his headquarters by 8:00 p.m. for a conference with the German Foreign Minister Joachim von Ribbentrop and to be briefed on the latest developments from the St. Lô sector

FIG. 2. The small house of Rémy Miche where Field Marshal Rommel was carried by Captain Lang immediately after the accident of 17 July 1944.

where pressure from the Americans threatened a breakthrough. These daily front line inspection tours were dangerous, and care was exerted by Rommel's staff because the United States Army Air Force and the Royal Air Force had all roads covered by their fighter commands.

This particular afternoon was no exception and the main roads were littered with burning and destroyed transport. After leaving Dietrich's headquarters near Caen, Sergeant Daniel drove through Falaise, St. Pierre-sur-Dives, and on toward Livarot which they approached from the west about 6:00 p.m. There were 8 dive bombers in the Livarot area and entrance was impossible, so they turned directly south on a covered lane which paralleled the main road to Vimoutiers. The command car, apparently unnoticed, crossed a small railroad and joined the main road approximately 2 miles from Vimoutiers. Field Marshal Rommel was sitting in the front seat of the open car to the right of Daniel with a map on his knees, and Captain Lang was in the rear immediately behind him.[3] Sergeant Holke was between Lang and Major Neuhaus acting as aircraft observer. Just after passing the rail crossing, Holke warned that two aircraft were diving on the road. Daniel was ordered to increase speed and then to turn onto a small side road off to the right about 300 yards ahead. There was a park and large grove of trees which led to a farm near Ste. Foy de Montgommery. Before the command car could reach shelter, the first fighter came in at low level and fired at 500 yards. Daniel was driving at 55 miles per hour, and at the time of the attack Rommel held on to the right door handle and looked back. At the same instant Captain Lang opened the rear door and jumped and landed in a ditch to the right of the road. The first burst of machine gun fire struck the left side of the car, wounding Daniel in the shoulder and arm so that the car spun out of control. It rammed a tree stump to the right of the road and then swerved in the ditch to the left. Major Neuhaus was wounded by shell fragments which fractured his pelvis, but Sergeant Holke was not injured. Field Marshal Rommel was struck in the face by shattered glass and was thrown clear of the car, falling on the pavement. He sustained a severe craniocerebral injury, was immediately unconscious, and lay motionless some 20 yards behind the wrecked car. A second low level attack followed, but no further damage or injury occurred. Captain Lang and Sergeant Holke ran out from shelter and carried the Field Marshal into a small cottage to the right of the highway, at the entrance of the side road where Daniel had

FIG. 3. The asile, La Providence, in Livarot where Field Marshal Rommel was treated by the pharmacist, Marcel Lescene.

[3]Captain Helmuth Lang has given a complete account of the accident and provided all of the essential details of the strafing on 17 July 1944. Without his help and co-operation, the important particulars of that afternoon would be missing.

been instructed to turn and avoid the aerial attack. This house belonged to Rémy Miche, a caretaker and farmer.

Rommel was unconscious; he was bleeding from his face and had a deep laceration over the left temporal region as well as a gross deformity of the contour of the skull in this area. There were multiple cuts about his left eye and mouth. Captain Lang then took Miche's bicycle and rode to Vimoutiers, which took about 10 minutes. He looked in vain for German Army medical aides and doctors and then commandeered a Kuebelwagon (jeep) and returned to the scene of the accident some 45 minutes later. In the meantime Rommel's wounds had been wrapped in scraps of cloth, and he and Daniel were placed in the vehicle and driven to Livarot. Captain Lang was then directed by German soldiers to the asile called La Providence, a Roman Catholic home for the aged kept by the nuns, which had been used as a shelter and aid station for wounded French civilians since 6 June 1944.

At 6:30 p.m. Marcel Lescene, the pharmacist of Livarot, left the home of a friend and walked toward the center of town.[4] Standing near the monument for the dead of the 1914 to 1918 War, the old pharmacist saw Captain Lang hurriedly ask a group of German soldiers for directions to the nearest medical help for the wounded Field Marshal. Then Lang asked Lescene the same questions and was told to proceed in the direction of Lisieux where doctors could be found. Captain Lang drove off and, for his part, Monsieur Lescene had an afternoon *apéritif* with his colleagues. When Lang returned within the hour he ordered the Mother Superior, Sister Isidore, to find Lescene. She sent a French civil defense worker who lived next to the asile, Jacques Bisson Raulin, to bring the pharmacist at once. Marcel Lescene arrived at the asile with Raulin and found the Field Marshal on the table in the small dining room. After he had examined the patient, Lescene made the diagnosis of a fracture of the petrous part of the left temporal bone, a perforation of the left tympanic membrane with blood coming from the external auditory canal; there was a fracture through the left orbital arch, and the patient was in deep coma. Lescene dressed the wounds

[4]Madame Mercel Lescene has provided an accurate description of her husband's activities on 17 July 1944, which has been of great interest and help.

FIG. 4. The table at La Providence where Rommel lay before Lescene arrived, about 1 hour after the accident. The fireplace and mantel are in the background.

and, to count the pulse, removed Rommel's wrist watch and placed it on the mantel over the fireplace. The pulse was weak and thready, and the patient was in shock. Lescene gave Rommel 2 ampules of camphorated oil intramuscularly and then recommended that he and Sergeant Daniel be taken to the Luftwaffe Hospital at Bernay immediately.

FIG. 5. The gate to the former Luftwaffe hospital at Bernay, 30 miles east of the accident. Field Marshal Rommel was brought here at about 8:30 p.m. on 17 July and remained until 23 July 1944.

FIG. 6. The entrance to the hospital at Vésinet, St. Germain, near Paris where Field Marshal Rommel convalesced until 8 August 1944.

The front seat of a closed top limousine, which belonged to the commander of the garrison at Livarot, was removed and a mattress was put down. The two wounded men were placed in the car and then driven 25 miles to Bernay. The journey began about 7:30 p.m., and they reached the hospital almost an hour later. Captain Lang had to return to the wrecked command car to recover the Field Marshal's military maps which had been tucked in a side pocket but were not discovered by the French underground. Later that evening a Colonel of the German Army medical corps returned to Livarot and questioned Lescene about his diagnosis, and particularly the nature of the injections which Rommel had received. Then at 2:00 a.m. Lescene was summoned to the asile and was interrogated by another Wehrmacht officer; he was asked for the exact identity of the drug which he had given Rommel, and it had been noticed that the Field Marshal's wrist watch was missing. Lescene proceeded to sift the ashes of the fireplace and recovered the ampules; the wrist watch was found where it had been left, on the mantel above the fireplace. Lescene was thanked for his services, and as the pharmacist left he commented that Rommel probably had little chance of survival. The driver, Sergeant Daniel, had died that evening at Bernay in spite of several transfusions.

Rommel was taken to the second floor of the Malbranche pavilion of the Bernay Hospital, founded in 1697 by Madame de Ticheville and used during the German occupation by the Luftwaffe. Skull roentgenograms were made, and within hours Professor A. Esch arrived from Paris to examine the patient. It is Captain Lang's recollection, however, that Esch did not arrive until the following morning. Professor Esch[5] was a graduate of Leipzig and the Neurosurgical Consultant to the Luftwaffe; today he practices otolaryngology at Boppard-on-Rhine. By the time Professor Esch reached Bernay, Field Marshal Rommel had become restless and was given morphine, chloral hydrate, and barbiturates for sedation. There was a cerebrospinal fluid rhinorrhea, and lumbar puncture revealed a clear fluid with no blood. In addition, there was a complete left oculomotor nerve lesion. It was Esch's opinion that the temporal fracture was not depressed, and Rommel had no major motor deficit and responded to strong sensory stimuli. There were no fractures of the extremities and no evidence of visceral injury. Esch ruled out the diagnosis of subdural hematoma and an extradural hemorrhage; it was his judgment that there were no surgical indications. During the next several days the lumbar punctures were repeated, and the patient's state of consciousness improved. It soon became evident to Professor Esch that the Field Marshal was totally deaf in the left ear and, aside from the oculomotor palsy, there was no further

[5]I am indebted to Prof. A. Esch of Boppard-on-Rhine who permitted details of treatment of his patient to be published.

FIG. 7. Captain Helmuth Lang (center) who was sitting behind Field Marshal Rommel at the time of the strafing incident on 17 July 1944.

change. The Field Marshal was right-handed, and there was no expressive or receptive aphasia.

As Rommel recovered at Bernay, he was difficult to manage and keep at rest. The cerebrospinal fluid leak fortunately closed, there was no evidence of meningitis, and he had no posttraumatic convulsions. Within 3 to 4 days he had become quite energetic, and in a half serious, half humorous way, the Field Marshal would threaten Professor Esch with his rank to force his own way but was unsuccessful. His friends, General Hans Speidel and Admiral Friedrich Ruge, visited on 22 July 1944 at Bernay, and found him sitting on the edge of the bed, having dressed against the orders of his doctor (4). Rommel had wished to shave, but this was forbidden. At this time his left eye was closed, and his face showed signs of being severely bruised. They discussed the situation at the front, and the progress of the battle in Normandy. On Sunday, 23 July 1944 at 5:00 a.m., Field Marshal Rommel started the journey from Bernay to the thousand bed hospital at Vésinet in St. Germain, a suburb of Paris. He made the trip in a command car which had been converted into a makeshift ambulance. Boards and a mattress had been placed down so that he could get some rest on the way. They drove at 10 to 15 miles per hour because of the bombed roads and bridges and reached their destination some 4 hours later. That afternoon Rommel was again examined by Esch who found that he was rapidly improving. Admiral Ruge visited Rommel on each of the 3 succeeding days, and they talked of the Channel defenses which had been planned the previous spring, and on one occasion the Field Marshal told the story of how he won the Pour le Mérite in the First War.[6] Ruge read to him, and the nurse in charge commented that Rommel was a good patient; he was quartered on the second floor in a large room with a bath, in the corner of the right wing of the Vésinet Hospital. On 24 July 1944 Rommel wrote his wife a letter which was dictated and which he was unable to sign:

> I am now in hospital and being very well looked after. Of course I must keep quiet until I can be moved, which will be a fortnight yet. My left eye is still closed and swollen, but the doctors say that it will get better. My head is still giving me a lot of trouble at night, though I feel very much better in the daytime (2).[7]

[6]Vice Admiral Friedrich Ruge has given me important information concerning the Field Marshal following the accident and has permitted quotation from his diary (4).

FIG. 8. Monsieur Marcel Lescene, the pharmacist of Livarot, who first treated Field Marshal Rommel after the accident on 17 July 1944. Photograph by R. Tesnière.

A detailed report of the accident was made to the High Command and German Press although there was never a formal radio or newspaper announcement. As Rommel recovered he was anxious that the facts of his injury be known and that he was not in command of the German Army in France. Because there was no official announcement of the strafing incident and his hospitalization, Rommel believed that Hitler intended to blame him directly for the deteriorating military situation for which he was no longer responsible. On the morning of 1 August 1944, there was a 2 hour press conference at Vésinet Hospital which ended rather abruptly when he was asked whether or not the head injury had been sustained as a result of shellfire or indirectly when he had been thrown from the command car. Rommel was greatly annoyed because the implication was made that he was a noncombatant and, therefore, not eligible for

[7]Captain B. H. Liddell-Hart has reviewed the manuscript and generously permitted quotation from his *The Rommel Papers.*

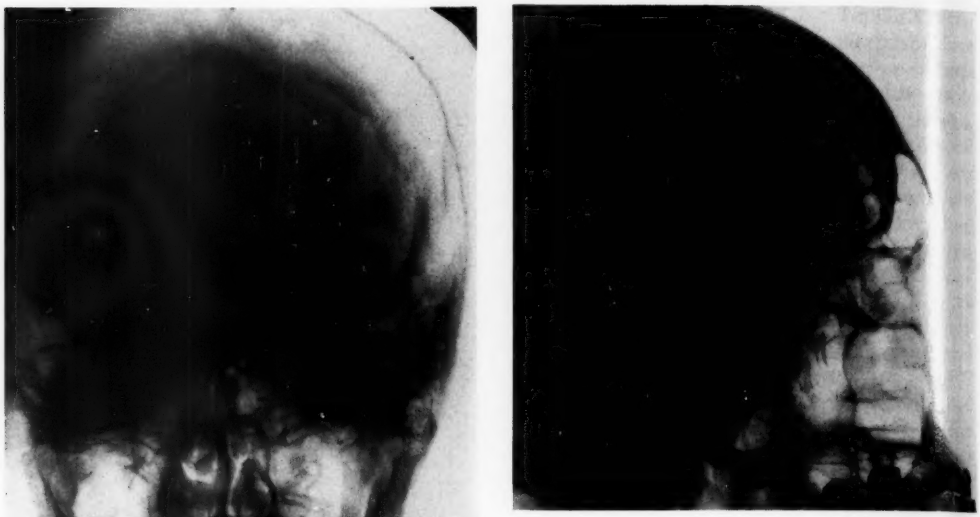

FIG. 9. Anteroposterior and lateral roentgenograms of the skull made at the Luftwaffe Hospital in Bernay, France, to which Rommel was taken on 17 July 1944. The diagnosis was "severe fracture of the base of the skull running from the right cheek bone through the ethmoid cells and up to the sella turcica."[8]

a wound decoration, a point of honor with every German soldier.

During the following week the discoloration about his face and eye disappeared, and the blood pressure, pulse, and temperature became normal for the first time. General Speidel convinced Rommel that he must be patient and remain in the hospital until fit for discharge to his home at Herrlingen. The return journey was made on 8 August 1944 and required a full day. Rommel was accompanied by Professor Esch and his wife as well as Doctor Shenning of Army Group B. Shortly after the Field Marshal arrived home, his son Manfred wrote:

> My father, his left eye covered with a black bandage, sat in an arm chair beside a low coffee table. The left half of his face had been crushed by the weight of the blow he had received. He raised himself shakily to his feet and we exchanged greetings. "I still get headaches and my left eye is closed and won't move. But it will all get better." (3).

He was put under the care of Professors Albrecht (Ophthalmology) and Stock (Neurosurgery) at the University Clinic in Tübingen, and his progress was excellent. August passed quietly, and Rommel convalesced well and kept an active correspondence with General Speidel and Admiral Ruge. On 6 September 1944 Speidel found the Field Marshal in good spirits, lively, and noted that his left eye was half open (7). During September the Rommel family learned that they were being watched closely by the Gestapo, and the Field Marshal was warned by friends that he was suspected of being an accomplice in the 20 July bomb plot.

At noon 14 October 1944, General Wilhelm Burgdorff and General Ernst Maisel came to the Rommel home in Herrlingen under the pretext of discussing a new command in Russia, but Rommel was accused of having been a key figure in the July conspiracy. He was given barely 2 hours to decide whether or not he would face a People's Court, be found guilty and hanged, or take his own life by poison. He made the first choice but was reminded that if he decided to make an issue of the matter his wife and son

[8]Brigadier General S. L. A. Marshall (U.S.A., ret.), Historian for the European Theater of Operations, has read this account and made valuable suggestions. He has permitted reproduction of the roentgenograms of Rommel's skull and a photograph made following the accident.

FIG. 10. Photograph of Field Marshal Erwin Rommel taken on 23 July 1944 at Vésinet Hospital by Baron von Esebeck, the German war correspondent, showing ptosis of the left eyelid. At this time Rommel was convalescing from the craniocerebral injury sustained when his command car was strafed. Following a press conference, Rommel donned his uniform jacket over his pajamas for this photograph which was obviously retouched by the photographer. The purpose of posing for the photograph was to publicize the fact that Rommel was not in active command of the German defensive disposition of troops on that date.[8]

would no longer be safe. The streets and grounds of their home had been surrounded so there was never any question of resistance or escape. After a brief farewell to his family and aide, Captain Hermann Aldinger, he left never to return. Thirty minutes later, Frau Rommel was telephoned and told that her husband had suffered from a "brain hemorrhage" and had died on the way to Berlin. Later Captain Aldinger drove to the hospital in Ulm, identified Field Marshal Erwin Rommel, and was told that an autopsy had been forbidden by the higher authorities.

Brigadier Desmond Young[9] has commented

[9]Brigadier Desmond Young has permitted the use of important material and quotations from his remarkable biography, *Rommel*, Collins, London, 1950. He has read the manuscript and made helpful suggestions.

FIG. 11. Dr. Charles Capers-Smith, former battalion surgeon U. S. 2nd Armored Division, has provided probably the last known photograph of Field Marshal Rommel before his accident. This picture was on a roll of film in the camera of a wounded Panzer captain who surrendered to Capers-Smith near Thury-Harcourt in July 1944.

that the Nazis truly had a flair for the dramatic as well as an exquisite mortuary sense. National mourning was ordered by Hitler, and Rommel was buried with full military ceremonies. The coffin was taken from Herrlingen to the town hall in Ulm, some 10 miles away, accompanied by an honor guard. The ranking officer of the Wehrmacht, Field Marshal Gerd von Rundstedt, extolled Rommel and his campaigns and referred to his "pitiless destiny." Rommel is buried in the corner of the small churchyard in Herrlingen, and his grave is marked by a simple wooden military cross seen in so many German cemeteries today. It is a quiet place with green shrubbery and shaded by tall trees.[10]

It is interesting to speculate what turn of events might have taken place had Rommel been spared the misfortune of 17 July 1944. There is little room for doubt among his closest military associates, friends, and family that, had he been able, he would have rallied the German Army to overthrow Hitler and the Third Reich. He most probably would have chosen this course whether or not the explosion had claimed Hitler its victim. When it became known that Hitler

[10]Franz Selinger has been of invaluable aid in the preparation of this account and has offered encouragement during the several years of its preparation. He has provided important translations and other articles concerning Field Marshal Rommel. An extensive correspondence and visits with him and his family have made this a most pleasant undertaking.

had survived on 20 July 1944, a near panic seized the leaders of the conspiracy, as evidenced by the number of suicides. The need for a calm, resolute leader was essential, and as Rommel lay unconscious at Bernay, none could summon the required courage and boldness. Rommel expressed many times to his confidants this general theme, "the sky over Germany has grown very dark." His realization that Germany could not win the War was complete by the time of D-day in Normandy, and from then on he was plagued by the dichotomous situation of his duties as a soldier and knowledge that the only hope for his country and its youth was surrender, before all was lost. This latter conviction was a strong one and would have prompted bold initiative on Rommel's part and action against Hitler and his SS Army.

But chance, fate, whatever one might call it, barred the way of the one who would have taken the responsibility of sparing his country a total destruction. Rommel was the man who could have rendered Germany a priceless service and destroyed Hitler and the Nazi system from within. The "might have been" situations in this instance are numerous, for his stature as a leader and person were such that possibly he could have led postwar Germany in a democratic political movement and made a major contribution to a United Western Europe. Most military historians of World War II are agreed that Rommel was one of the great captains. His military aptitude and genius were exceptional, and often his greatest successes against a superior enemy could be explained only in terms of leadership and personal command. He was respected, in short, idolized by his troops as few field commanders have been in modern warfare. The development of a political conscience, insight, and responsibility to his country's future came late in his life, and these attributes could have been molded into great peacetime leadership. This potential was never fully realized, perhaps cut short one July day, on a road in Normandy.

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Reviews of New Books

Modern Trends in Urology. Second Series. Edited by Sir Eric Riches, M.C., M.S., F.R.C.S. 287 pages, 123 illustrations. $16.00. New York: Paul B. Hoeber, Inc., 1960.

Reviewed by Clarence V. Hodges

Again this compendium on the current concepts of basic mechanisms, diagnosis, and treatment in urologic disease has been edited by Sir Eric Riches. There are 27 contributors, each a well known authority in his assigned subject. The coverage of currently vital topics is excellent; the only disappointing deficiency is the lack of consideration given to cancer chemotherapy in urology.

The contributions of the various writers have been well integrated, and repetition is almost absent. There is a reasonable amount of experimental work interspersed, such as W. J. Dempster's contribution on the experimental aspects of renal transplantation, with how-to-do articles, such as that on renal biopsy. The section on "Use of the Image Intensifier in Urology" is an admirable treatise on the flow of urine from the renal calyces to the external urethral meatus. The reproduction of the spot-film roentgenograms is unusually good. The text is easy reading, and the illustrations are of uniformly high quality.

All urologists interested in keeping abreast of current urologic thinking and events and other surgeons and internists, concerned with urologic problems, will want to refer to this book frequently.

Surgical Urology. By R. H. Flocks, M.D., and David Culp, M.D. 2nd ed. 430 pages, 126 illustrations. $10.50. Chicago: Year Book Publishers, Inc., 1961.

Reviewed by Frederick A. Lloyd

The first edition of Flocks's and Culp's *Surgical Urology* was published in 1955. The second edition, published this year, includes many of the advances which have been made in the intervening years. These include the newer techniques of pyeloplasty, urinary diversion, orchiopexy, bilateral retroperitoneal node dissection, and prostatic biopsy. An entirely new section is included on the use of segments of small and large bowel for various plastic procedures on the urinary tract.

This edition, like the first, is beautifully illustrated with well executed line drawings. In all, there are 126 tables, each of which has from 2 to 5 separate drawings. These demonstrate the essential steps of each operation. The accompanying text is brief but to the point. Several sections on the anatomy and physiology of urinary and genital tracts are also included.

This excellent little volume has more of the character of an atlas than a textbook. It does, however, contain a surprising amount of practical information. It should prove of interest to the practicing urologist as well as the urologic resident.

The Surgery of Mitral Stenosis. By Robert P. Glover, M.D., M.S. (Surg.), F.A.C.S., F.A.C.C., and Julio C. Davila, M.D., F.A.C.S., F.A.C.C. 195 pages, 41 illustrations. $9.50. New York and London: Grune & Stratton, 1961.

Reviewed by Saul A. Mackler

This monograph is the product of the authors' experience with 1,000 surgically treated patients with mitral stenosis. It is a concise and factual presentation of the clinical and anatomic problems involved and their methods of management.

The anatomy and pathology of the mitral valve is shown in relationship to other intracardiac landmarks as it confronts the surgeon. The motion of the valve as it is activated by blood flow and the effects produced by deformity are illustrated by diagrams and photographs. The explanation of the hemodynamic changes in mitral valve disease and their clinical interpretation correlates well with the illustrated lesions. The succeeding chapters are concerned with the preoperative, operative, and postoperative management of the patient. The results of mitral commissurotomy during a 12 year period are analyzed on the basis of change in the clinical picture, supplemented by laboratory data, at various intervals of time. The substance of the accumulated material is collected in an appendix in the form of tables and graphs for easy visualization and comparison of data.

There are many aspects of mitral valve disease on which there is no unanimity of opinion, and the authors have expressed themselves on some which might invite controversy: the mechanism of leaflet fusion, the use of a mechanical dilator, and the occurrence of restenosis, which they question. The statistical data, however, are in conformity with the reported average.

This monograph is a concise, clearly expressed presentation based on clinical experience and directed toward those interested in the treatment of mitral stenosis.

Atlas of Obstetric Technic. By J. Robert Wilson, M.D., M.S. 301 pages, illustrated. $14.50. St. Louis: The C. V. Mosby Co., 1961.

Reviewed by Byford F. Heskett

This is a beautiful book printed on good paper stock with very legible printing. It is profusely illustrated by Daisy Stilwell with easy to understand diagrams depicting the various techniques. The diagrams are on the right hand page and the explanatory notes on the left. There are some 301 pages, including an index, with 14 chapters.

This is, in reality, much more than an atlas because, in addition to the splendid illustrations of operative techniques with detailed explanatory notes, it contains several worthwhile chapters. The first chapter,

for example, defines and explains what an adequate maternity service should be, including professional staff and labor and delivery room facilities. There are chapters upon "Normal Labor and Delivery," "Third Stage of Labor and Postpartum Hemorrhage," "Induction of Labor," and "Placenta Praevia."

This type volume has many uses—the training of students, interns, and residents, and as a refresher for doctors who are not constantly operating.

The author can take great pride in a very tedious and difficult task extremely well done. I know of no other comparable concise publication.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

Die Erkrankungen der Gallenwege und des Pankreas. By Dr. Walter Hess. 660 pages, 266 illustrations. $35.50. Stuttgart: Georg Thieme, 1961.

Techniques of Thoracotomy. By B. T. LeRoux, M.B., Ch.B., F.R.C.S.E. 21 pages, 65 illustrations. $11.00. Edinburgh and London: E. & S. Livingstone Ltd., 1961; Baltimore: Williams & Wilkins Co., exclusive U. S. agents.

Management of Obstetric Difficulties. Revised by J. Robert Wilson, M.D., M.S. 6th ed. 663 pages, 323 illustrations. $16.50. St. Louis: The C. V. Mosby Co., 1961.

Glaucoma; Chemistry Mechanisms and Therapy. By Sidney Lerman, M.D.C.M. 105 pages, 25 illustrations. $6.00. Springfield, Ill.: Charles C Thomas, 1961.

Progress in Clinical Surgery. Edited by Rodney Smith, M.S., F.R.C.S. Series II. 321 pages, 110 illustrations. $11.50. Boston: Little, Brown & Co., 1961.

Resuscitation of the Unconscious Victim; a Manual for Rescue Breathing. By Peter Safar, M.D., and Martin C. McMahon. 2nd ed. 79 pages, 15 illustrations. $2.00. Springfield, Ill.: Charles C Thomas, 1961.

The Spinal Cord; Basic Aspects and Surgical Considerations. By George Austin. 501 pages, 363 illustrations. $26.50. Springfield, Ill.: Charles C Thomas, 1961.

Orthopaedic Approaches; a Stereographic Manual. By John J. Joyce III, M.D., B.A., and Michael Harty, M.A., M.B., M.Ch., F.R.C.S.(Eng.). Section 1: Lower Extremity, Reels 1 to 18. 75 pages, 10 illustrations. $28.00. Baltimore: The Williams & Wilkins Co., 1961.

Bone; an Introduction to the Physiology of Skeletal Tissue. By Franklin C. McLean, Ph.D., M.D., and Marshall R. Urist, M.D. 2nd ed. 252 pages, 35 illustrations. $6.00. Chicago: The University of Chicago Press, 1961.

The Closed Treatment of Common Fractures. By John Charnley, B.Sc., M.B., F.R.C.S. 269 pages, 215 illustrations. $10.00. Baltimore: The Williams & Wilkins Co., 1961.

Inflammation and Diseases of Connective Tissue; a Hahnemann Symposium. Edited by Lewis C. Mills, M.D., and John H. Moyer, M.D. 885 pages, illustrated. $16.00. Philadelphia and London: W. B. Saunders Co., 1961.

Abdominal Surgery. By 41 authors. Edited by Arthur W. Allen, M.D., and David Woolfolk Barrow, M.D. Foreword by Frederick A. Coller, M.D. 658 pages, 542 illustrations. $21.50. New York: Paul B. Hoeber, Inc., Medical Division of Harper & Bros., 1961.

Bibliotheca Gastroenterologica. Fasc. 3. By H. J. Fahrlander, Basel. Ileus; Klinik, Radiologie, und Therapie. By R. Nissen and E. Hafter. 112 pages, illustrated. $6.00. Basel and New York: S. Karger, 1961.

Pregnancy and Diabetes Mellitus. By Lars Hagbard, M.D. 101 pages, illustrated. $6.75. Springfield, Ill.: Charles C. Thomas, 1961.

Abdominal Operations. By Rodney Maingot, F.R.C.S. 4th ed. 1367 pages, illustrated. $29.50. New York: Appleton-Century-Crofts, Inc., 1961.

Calderwood's Orthopedic Nursing. By Carroll B. Larson, M.D., F.A.C.S., and Marjorie Gould, R.N., B.S., M.S. 5th ed. 532 pages, 343 illustrations. $6.50. St. Louis: The C. V. Mosby Co., 1961.

The Cardiac Arrhythmias; a Guide for the General Practitioner. By Brendan Phibbs, M.D. 122 pages, illustrated. $7.50. St. Louis: The C. V. Mosby Co., 1961.

Heredity in Ophthalmology. By Jules Francois. 705 pages, 629 illustrations. $23.00. St. Louis: The C. V. Mosby Co., 1961.

Control of Ovulation; Proceedings of the Conference Held at Endicott House, Dedham, Massachusetts, 1960. Edited by Claude A. Villee. 243 pages, illustrated. $10.00. New York, Oxford, London, and Paris: Pergamon Press, Symposium Publications Division, 1961.

Hospitals, Doctors, and Dollars. By Robert M. Cunningham, Jr. 268 pages, no illustrations. $6.95. New York: F. W. Dodge Corp., 1961.

Illustrating Medicine and Surgery. By Margaret C. McLarty, D.A.(Edin.). Foreword by Sir Robert Macintosh, M.A., D.M., F.R.C.S.(Edin.), D.A. 155 pages, 178 illustrations. $8.50. E. & S. Livingstone Ltd., 1960; Baltimore: The Williams & Wilkins Co., exclusive U. S. agents.

Recent Advances in Biological Psychiatry. Edited by Joseph Wortis, M.D. Vol. III. 236 pages, illustrated. $9.75. New York and London: Grune & Stratton, 1961.

AMERICAN COLLEGE OF SURGEONS

I. S. RAVDIN, Philadelphia, *President*

ROBERT M. ZOLLINGER, Columbus, Ohio, *President-Elect*

PRELIMINARY PLANS FOR THE 47TH CLINICAL CONGRESS THE CONRAD HILTON HOTEL, CHICAGO, ILLINOIS 2 THROUGH 6 OCTOBER 1961

IN THIS ISSUE, the 9 Postgraduate Courses to be given at this year's Clinical Congress are outlined. The purpose of these courses is to provide, within four 3 hour sessions, as much current information as possible upon advances in surgery. The scope of the courses is to review a limited field thoroughly, rather than a broader subject sketchily, within the allotted time. Courses are planned with particular care in order that they proceed by co-ordinated progressive steps from basic facts to application to patients.

They are designed especially for the surgeon whose opportunities for contact with research and graduate teaching are limited and for serious students who intend to pursue an entire course rather than for the occasional visitor with an hour or a half day to occupy.

With one exception, all courses will be held mornings, Tuesday through Friday, from 8:30 to 11:30. The course on thoracic surgery will be held afternoons, Monday through Thursday, from 1:30 to 4:30. Because seating will be limited for all of these classes, it is advisable to register for the course of your choice as quickly as possible. The fee is $10.00, and admission will be by ticket only. Official registration forms may now be procured by writing to the College headquarters at 40 East Erie Street, Chicago 11, Illinois.

Preoperative and Postoperative Care

JAMES D. HARDY, Jackson, *Chairman*

Tuesday through Friday, 8:30–11:30 a.m.

THE ALIMENTARY TRACT

JAMES D. HARDY, Jackson, Moderator.

The Esophagus—Relation of Preoperative and Transoperative Factors to Postoperative Problems and Success. F. HENRY ELLIS, JR., Rochester, Minnesota.

The Stomach—Influence of Preparation and Operation on Postgastrectomy Complications; Management. RICHARD L. VARCO, Minneapolis.

The Small Bowel—Postoperative Problems: Insufficiency, Obstruction, and Fistulas; Management. CLAUDE E. WELCH, Boston.

The Lower Rectum and Anus—Preoperative and Postoperative Care in Tumor, Fistula-in-Ano, and Hemorrhoids. MERRILL O. HINES, New Orleans.

Further Questions and Case Analysis Clinic. WARREN H. COLE, Chicago, Presiding, with other participants of the session and WALTER L. PALMER, Chicago.

THE HEPATOBILIARY TRACT, SPLEEN, AND PANCREAS

J. ENGLEBERT DUNPHY, Portland, Oregon, Moderator.

Portacaval Shunt for Hemorrhage or Ascites; Preoperative and Postoperative Care and Clinical Results. LOUIS M. ROUSSELOT, New York.

The Common Bile Duct—Some Diagnostic, Technical, and Management Problems. HARWELL WILSON, Memphis.

Pancreatic Surgery—Preparation, Decisions at Laparotomy, and Management of Complications. CHARLES B. PUESTOW, Chicago.

Hypersplenism—Newer Data, Conservative Versus Operative Management, and Postoperative Difficulties. ROGER D. WILLIAMS, Columbus.

Further Questions and Case Analysis Clinic. FRANK

GLENN, New York, Presiding, with other participants of the session.

THYROID SURGERY, PULMONARY RESECTION, AND VASCULAR PROCEDURES

ALTON OCHSNER, New Orleans, Moderator.

Thyroid Cancer—Changing Patterns of Preoperative, Transoperative, and Postoperative Management. GEORGE CRILE, JR., Cleveland.

Pulmonary Resection—Preoperative Evaluation and Postoperative Complications; Management. WATTS R. WEBB, Jackson.

Hernias of the Diaphragm—Preoperative, Transoperative, and Postoperative Management. CONRAD R. LAM, Detroit.

The Aorta and Its Branches—Preoperative, Transoperative, and Postoperative Management of Intestinal, Renal, and Extremity Ischemia. JAMES D. HARDY, Jackson.

Vena Caval Ligation for Thromboembolism—Indications, Results, and Sequelae. JAMES A. KIRTLEY, JR., Nashville.

Further Questions and Case Analysis Clinic. CHARLES ROB, Rochester, New York, Presiding, with other participants of the session.

SYMPOSIUM ON SUPPORTIVE MEASURES IN SURGERY

HENRY T. RANDALL, New York, Moderator.

Blood and Nutrition—Guides for Replacement of Acute and Chronic Blood Loss, and Support of the Chronically Ill. CURTIS P. ARTZ, Jackson.

Fluid and Blood Replacement in Infants. WILLIAM B. KIESEWETTER, Pittsburgh.

Pituitary and Adrenal Ablations—Preoperative Preparation and Postoperative Management. CHARLES ECKERT, Albany, New York.

Anesthesia—Safety Factors, Pitfalls, and Management of Complications. LEONARD W. FABIAN, Jackson.

Postoperative Oliguria—Differential Diagnosis and Management. FRANCIS D. MOORE, Boston.

Gastrointestinal Disease

STANLEY O. HOERR, Cleveland, *Chairman*

Tuesday through Friday, 8:30–11:30 a.m.

PEPTIC ULCER

LESTER R. DRAGSTEDT, Gainesville, Moderator.

Physiologic Basis for Peptic Ulcer. GEORGE A. HALLENBECK, Rochester, Minnesota.

Symposium on Treatment of Duodenal Ulcer:

Treatment by Gastric Resection. WILLIAM H. REMINE, Rochester, Minnesota.

Treatment by Vagotomy and Hemigastrectomy. REGINALD H. SMITHWICK, Boston.

Treatment by Vagotomy and Posterior Gastrojejunostomy. H. A. OBERHELMAN, JR., Palo Alto.

Treatment by Vagotomy and Pyloroplasty. JACK M. FARRIS, Los Angeles.

Panel: Treatment of Complications of Peptic Ulcer: Hemorrhage, Perforation, Obstruction. JACK M. FARRIS, Los Angeles, Presiding, with other participants of the session.

SPECIAL PROBLEMS IN GASTRODUODENAL SURGERY

ANGUS D. MCLACHLIN, London, Ontario, Moderator.

Management of Marginal Ulcer. WALTER C. MACKENZIE, Edmonton, Alberta.

Panel: Symptoms Following Gastric Surgery: Cause, Prevention, Treatment. WALTER C. MACKENZIE, Edmonton, Presiding. Panelists: WILLIAM E. ABBOTT, Cleveland, ROBERT J. COFFEY, Washington, and MARK A. HAYES, New Haven.

Gastric Cooling for Upper Gastrointestinal Tract Bleeding. STEPHEN L. WANGENSTEEN, New York.

Management of Esophageal Varices. ROBERT R. LINTON, Brookline, Massachusetts.

Management of Gastric Ulcer. JOEL W. BAKER, Seattle.

Gastric Neoplasms—Management and Prognosis. STANLEY O. HOERR, Cleveland.

Chemotherapy in Gastrointestinal Malignant Disease. ANTHONY R. CURRERI, Madison.

SMALL INTESTINE AND COLON: INFLAMMATORY DISEASES

L. KRAEER FERGUSON, Philadelphia, Moderator.

Surgical Pathology of Inflammatory Diseases of Small Intestine and Colon. L. KRAEER FERGUSON, Philadelphia.

Regional Enteritis. WILEY F. BARKER, Los Angeles.

Ulcerative Colitis. RUPERT B. TURNBULL, Cleveland.

Diverticulitis. R. KENNEDY GILCHRIST, Chicago.

Panel: Inflammatory Disease of Small and Large Intestine, Including Appendicitis. RUPERT B. TURNBULL, Cleveland, Presiding, with other participants of the session.

SMALL INTESTINE AND COLON: SPECIAL PROBLEMS

ROBERT T. TIDRICK, Iowa City, Moderator.

Panel: Intestinal Obstruction. RUDOLF J. NOER, Louisville, Presiding. Panelists: JACK W. COLE, Cleveland, COLIN C. FERGUSON, Winnipeg, and ORVAR SWENSON, Chicago.

Intestinal Fistulas. CHARLES D. BRANCH, Peoria.

Neoplasms of the Colon:

Polyps and Polyposis. JACK W. COLE, Cleveland.

Cancer of the Rectum. CHARLES W. MAYO, Rochester, Minnesota.

Cancer of Colon, Excluding Rectum. CARL E. LISCHER, St. Louis.

Diseases of the Liver, Biliary Tract, and Pancreas

BEN EISEMAN, Lexington, Kentucky, *Chairman*

Tuesday through Friday, 8:30–11:30 a.m.

LIVER

BEN EISEMAN, Lexington, Moderator.

Liver Function and Liver Enzyme Tests. C. BARBER MUELLER, Syracuse.

Hypothermia and Anesthesia in Patients with Liver Disease. WILLIAM W. SHINGLETON, Durham.

Jaundice Simulating Extrahepatic Biliary Obstruction. BEN EISEMAN, Lexington.

Antibiotics in Hepatic and Biliary Tract Surgery. W. A. ALTEMEIER, Cincinnati.

Intrahepatic and Perihepatic Abscess. G. HUGH LAWRENCE, Seattle.

Liver Injuries. JOHN M. HOWARD, Philadelphia.

Surgical Implications of Pancreatic Insufficiency. ALEXANDER H. BILL, JR., Seattle.

ACUTE CHOLECYSTITIS

HENRY N. HARKINS, Seattle, Moderator.

Timing of Operation in Acute Cholecystitis. JOHN M. BEAL, New York.

Operative Cholangiography; Indications, Technique, Yield. HENRY N. HARKINS, Seattle.

Primary Closure of the Common Duct. SAM E. STEPHENSON, JR., Nashville.

Reconstruction of Common Duct. RICHARD B. CATTELL, Boston.

The Retained Stone. LAWRENCE G. HAMPSON, Montreal.

Panel: Cholecystitis. HENRY N. HARKINS, Seattle, Presiding. Panelists: JOHN M. BEAL, New York, and RICHARD B. CATTELL, Boston. (a) Anatomic Abnormalities, (b) Cholecystotomy, (c) Choledochotomy; (d) Duodenotomy; (e) Acalculous Cholecystitis; (f) Silent Stone; (g) Cholecystitis in Aged.

PORTAL HYPERTENSION

W. DEAN WARREN, Charlottesville, Moderator.

Management of Acute Esophageal Bleeder. MARSHALL J. ORLOFF, Los Angeles.

Indications and Contraindications for Shunts. W. DEAN WARREN, Charlottesville.

Preoperative and Postoperative Care of the Shunted Patient. LLOYD M. NYHUS, Seattle.

Extrahepatic Causes for Portal Hypertension. RICHARD M. PETERS, Chapel Hill.

Operations for Ascites. WILLIAM V. MCDERMOTT, JR., Boston.

Peptic Ulcer and Shunts. WILLIAM SILEN, San Francisco.

Panel: Indications and Techniques of Various Types of Shunts. WILLIAM V. MCDERMOTT, JR., Boston, Presiding. Panelists: WILLIAM SILEN, San Francisco, W. DEAN WARREN, Charlottesville.

LIVER AND PANCREAS

MERLIN K. DUVAL, JR., Oklahoma City, Moderator.

Neonatal Jaundice—Diagnosis and Surgical Management. THOMAS C. MOORE, Muncie.

Indications and Technique of Hepatic Resection. RENE B. MENGUY, Oklahoma City.

Pancreatic Tumors and Peptic Ulcer. GEORGE L. JORDAN, JR., Houston.

Retrograde Pancreatic Drainage in Pancreatitis. MERLIN K. DUVAL, JR., Oklahoma City.

Biliary Tract Drainage in Pancreatitis. ALAN G. THOMPSON, Montreal.

Pancreatectomy for Carcinoma; a Critical Evaluation of Palliation Versus Cure. RICHARD H. EGDAHL, Richmond.

Cardiovascular Surgery

IVAN W. BROWN, JR., Durham, *Chairman*

Tuesday through Friday, 8:30–11:30 a.m.

VASCULAR SURGERY

RALPH A. DETERLING, JR., Boston, Moderator.

Anomalies of the Aortic Arches. HERBERT SLOAN, Ann Arbor.

Dissecting Aneurysms of the Aorta. MICHAEL E. DEBAKEY, Houston.

Occlusive Disease of Branches of the Aortic Arch. E. STANLEY CRAWFORD, Houston.

Thrombectomy in Iliofemoral Venous Occlusive Disease. JAMES A. DEWEESE, Rochester, New York.

Vena Caval Ligation—Indications and Sequelae. WILLIAM G. ANLYAN, Durham.

Use of Anticoagulation and Fibrinolytic Agents in Vascular Surgery. RICHARD WARREN, Boston.

Panel Discussion. Moderator with other participants.

HYPOTHERMIA IN CARDIAC SURGERY

W. C. SEALY, Durham, Moderator.

Physiology of Perfusion Hypothermia. FRANK GOLLAN, Coral Gables.

Use of Perfusion Hypothermia with Pump-Oxygenator. FRANK GERBODE, San Francisco.

Experience with Profound Hypothermia Without an Oxygenator. CHARLES DREW, London, England.

Experimental Studies of Cerebral Oxygen Tension During Circulatory Arrest Under Deep Hypothermia. BYRON M. BLOOR, Morgantown.

Anesthesia and Drugs During Deep Hypothermia. BRIAN DAWSON, Rochester, Minnesota.

Metabolic Features of Deep Hypothermia. WILLIAM E. NEVILLE, Cleveland.

Use of Differential Cardiac Hypothermia. CHARLES A. HUFNAGEL, Washington.

Panel Discussion: F. JOHN LEWIS, Chicago, Presiding, with other participants of the session.

CERTAIN PROBLEMS OF CONGENITAL HEART DISEASE

EGBERT H. FELL, Chicago, Moderator.

Tetralogy of Fallot:
Present Place for Systemic-Pulmonary Artery Shunt. H. WILLIAM SCOTT, JR., Nashville.
Use of Superior Vena Cava-Pulmonary Artery Shunt. W. GLENN YOUNG, JR., Durham.
The Open Corrective Operation—Indications and Results. JOHANN L. EHRENHAFT, Iowa City.

Transposition of Great Vessels; Current Methods of Surgical Treatment. DWIGHT C. MCGOON, Rochester, Minnesota.

Ventricular Septal Defect Associated with Pulmonary Hypertension:
Pathophysiology and Selection of Patients for Operation. J. FRANK DAMMANN, JR., Charlottesville.
Technique and Results of Open Repair. HOWARD D. SIRAK, Columbus.
Place and Results of Banding Procedures. HAROLD M. ALBERT, New Orleans.

Panel Discussion. Moderator with other participants.

PROBLEMS OF EXTRACORPOREAL CIRCULATION

GEORGE H. A. CLOWES, JR., Cleveland, Moderator.

Prevention of Infection. C. FREDERICK KITTLE, Kansas City.

Vessel Damage from Cannulations. K. ALVIN MERENDINO, Seattle.

Pathologic Effects Particularly on the Central Nervous System. GEORGE MARGOLIS, Richmond.

Blood Effects and Their Sequelae. JAMES V. MALONEY, JR., Los Angeles.

ACQUIRED HEART DISEASE

GEORGE H. A. CLOWES, JR., Cleveland, Moderator.

Open Versus Closed Operation for Mitral Stenosis. HENRY T. NICHOLS, Philadelphia.

Mitral Insufficiency. JEROME HAROLD KAY, Los Angeles.

Aortic Insufficiency. HENRY T. BAHNSON, Baltimore.

Experimental and Clinical Experience with Left Heart Bypass Without Thoracotomy. CLARENCE DENNIS, Brooklyn.

Panel Discussion. Moderator with other participants.

Injury of the Joints of the Upper Extremity

SAM W. BANKS, Chicago, *Chairman*

Tuesday, 8:30–11:30 a.m.

SAM W. BANKS, Chicago, Moderator.

Fractures and Dislocations Involving the Interphalangeal and Metacarpal Phalangeal Joints. BURTON C. KILBOURNE, Chicago.

Impact on Wrist Function by Recent and Old Fractures of Carpal Navicula. J. J. CALLAHAN, Chicago.

Supination Treatment of Colles' Fracture. JOHN J. FAHEY, Chicago.

Reconstruction Procedures for Disabled Hands Following Trauma to the Wrist and Finger Joints. JOSEPH H. BOYES, Los Angeles.

Wednesday, 8:30–11:30 a.m.

GEORGE J. CURRY, Flint, Michigan, Moderator.

Treatment of the Painful Wrist, Secondary to Malunited Colles' Fractures, Alterations of the Radial-Ulnar Joint and Epiphyseal Injuries. JAMES E. BATEMAN, Toronto.

Fractures Encountered in and About the Elbow Joint in Children—Epicondyle, Lateral Condyle, and Supracondylar Injuries. FREDERICK M. SMITH, Falmouth, Massachusetts.

Modern Treatment of Comminuted Fractures of the Distal End of the Humerus Involving the Elbow Joint. WILLIAM H. BICKEL, Rochester, Minnesota.

Fractures and Fracture-Dislocations of the Elbow Associated with Major Injuries of the Head of the Radius and Olecranon Process. FLOYD H. JERGESEN, San Francisco.

Methods Found Useful in Restoring Function of Painful Joints Due to Trauma of the Upper Extremity. LOUIS B. NEWMAN, Chicago.

Thursday, 8:30–11:30 a.m.

CLINTON L. COMPERE, Chicago, Moderator.

Vascular Injuries in the Upper Extremity Associated with Trauma in and About the Major Joints. ORMAND C. JULIAN, Chicago.

Acute Dislocations and Fracture Dislocations of the Shoulder Joint. JOSEPH M. DZIOB, Buffalo.

Surgical Correction of Unrecognized Dislocations of the Shoulder. CARLO S. SCUDERI, Chicago.

Friday, 8:30–11:30 a.m.

ALFRED M. OKELBERRY, Salt Lake City, Moderator.

Fractures of the Head and Surgical Neck of the Humerus Which Influence Function of the Glenohumeral Joint. MOORE MOORE, JR., Memphis.

Acute and Chronic Conditions of the Acromioclavicular and Sternoclavicular Joints. NEWTON C. MEAD, Evanston.

Surgical Procedures for Improving Shoulder Function Following Trauma. HAROLD A. SOFIELD, Chicago.

Obstetrics and Gynecology

DAVID N. DANFORTH, Evanston, *Chairman.*

Tuesday through Friday, 8:30–11:30 a.m.

INFECTIONS

WOODWARD D. BEACHAM, New Orleans, Moderator.

Antibacterial Chemotherapy—Indications and Selection. HARRY B. HARDING, Evanston.

Septic Abortion—Management and Sequelae. HAROLD L. GAINEY, Kansas City, Missouri.
Postoperative Infections. CONRAD G. COLLINS, New Orleans.
Urinary Tract Infections in Obstetrics and Gynecology. T. N. EVANS, Ann Arbor.
Significance and Management of Intrapartum and Postpartum Fever. W. DOUGLAS FREW, Edmonton, Alberta.
Bacteremic Shock—Evaluation and Management. JOHN F. JEWETT, Boston.

ENDOCRINES

GEORGE B. MAUGHAN, Montreal, Moderator.
Diabetes and Prediabetes in Pregnancy. DAVID Y. HSIA, Chicago.
The Relation of Adrenal Cortical Activity to Gynecology. JAMES T. BRADBURY, Iowa City.
Hormone Therapy in Obstetrics. ROBERT B. WILSON, Rochester, Minnesota.
Hormone Therapy in Gynecology. SOMERS H. STURGIS, Boston.

SURGERY

ROBERT A. KIMBROUGH, JR., Chicago, Moderator.
Operations for Urinary Incontinence. JOHN C. ULLERY, Columbus.
Tubal Plastic Operations—Selection, Technique, Results. WILLIAM J. MULLIGAN, Brookline.
Vaginal Hysterectomy for Benign Disease—Indications, Technique. JOHN I. BREWER, Chicago.
Evaluation and Management of Varicose Veins in Pregnancy, Labor, and the Puerperium. JOHN H. OLWIN, Chicago.

GENERAL TOPICS

RALPH A. REIS, Chicago, Moderator.
Evaluation of Breast Lesions in Pregnancy. THADDEUS L. MONTGOMERY, Philadelphia.
Management and Outcome of Pregnancy in Rh Sensitized Patients. WILLIAM B. GODDARD, Iowa City.
Coagulation Defects in Obstetrics and Gynecology—Diagnosis and Treatment. C. PAUL HODGKINSON, Detroit.
Anemia in Pregnancy—Diagnosis and Management. FRANKLIN A. KYSER, Evanston.
Management of Threatened and Habitual Abortion. WALTER F. DILLON, Chicago.

Cancer Chemotherapy

HARRY S. MORTON, Montreal, *Chairman*
Tuesday through Friday, 8:30–11:30 a.m.

BASIC CONCEPTS IN CHEMOTHERAPY

HARRY S. MORTON, Montreal, Moderator.
Introduction—The Chemotherapy Course. HARRY S. MORTON, Montreal.
Cancer Chemotherapy National Service Center Program. STUART M. SESSOMS, Bethesda.
Introduction to Cancer Chemotherapy; Classification and Chemistry of Anticancer Drugs. THOMAS S. OSDENE, Radnor, Pennsylvania.
Biochemical Mechanisms of Action. CHARLES HEIDELBERGER, Madison.
Specific Actions of Drugs:
(1) Alkylating Agents; (2) Antibiotics. THOMAS S. OSDENE, Radnor, Pennsylvania.
(3) Antimetabolites, (4) Miscellaneous Cytotoxic Agents. CHARLES HEIDELBERGER, Madison.

SYSTEMIC CHEMOTHERAPY—ORAL AND INTRAVENOUS

ROBERT C. HICKEY, Iowa City, Moderator.
Principles of Chemotherapy and Dosimetry. ROBERT G. RAVDIN, Philadelphia.
Hormone Sensitive Tumors:
Breast. SAMUEL G. TAYLOR, III, Chicago.
Prostate. WILLET F. WHITMORE, JR., New York.
Ovary and Choriocarcinoma. JOHN G. MASTERSON, Brooklyn.
Solid Tumors:
Gastrointestinal Tract. ARTHUR G. JAMES, Columbus.
Lung. CHARLES A. ROSS, Buffalo.
Melanoma. JOHN S. STEHLIN, JR., Houston.
Other Solid Tumors Including Sarcoma. FRED J. ANSFIELD, Madison.
Discussion.

SPECIAL TECHNIQUES

DANELY P. SLAUGHTER, Chicago, Moderator.
Introduction to Regional Chemotherapy. CALVIN T. KLOPP, Washington.
Perfusion—Theory and General Application. EDWARD T. KREMENTZ, New Orleans.
Leakage Factor in Perfusion. JOHN S. STEHLIN, Houston.
Techniques of Perfusion of Specific Sites. KEITH REEMTSMA, New Orleans.
Infusion Techniques. FREDERIC P. HERTER, New York.
Wound Gavage and Instillation of Cancer Chemotherapeutic Agents at Surgery to Prevent Local Recurrence. GERALD OWEN MCDONALD, Chicago.
Discussion.

PRESENT STATUS OF CO-OPERATIVE ADJUVANT CHEMOTHERAPEUTIC STUDIES

JOSEPH H. FARROW, New York, Moderator.
Co-operative Adjuvant Studies of Veterans' Administration. LYNDON E. LEE, JR., Washington.
Co-operative Adjuvant Studies of the University Group. GEORGE E. MOORE, Buffalo.
Report of Adjuvant Chemotherapeutic Studies of Specific Sites:
Colon. HARRY W. SOUTHWICK, Chicago.

Stomach. JOHN M. BEAL, New York.
Breast. GEORGE E. MOORE, Buffalo.
Lung. ANTHONY R. CURRERI, Madison.
Ovary and Other Gynecologic Lesions. JOHN G. MASTERSON, Brooklyn.
Questions, Answers, and Discussion.

Thoracic Surgery

HIRAM T. LANGSTON, Chicago, *Chairman*
Monday through Thursday, 1:30–4:30 p.m.

BASIC PROBLEMS IN THORACIC SURGERY

HERBERT C. MAIER, New York, Moderator.
Estimation of Cardiopulmonary Function. EDWARD J. BEATTIE, JR., Chicago.
Respiratory Acidosis, Etiology, and Treatment. RICHARD M. PETERS, Chapel Hill.
Postoperative Assisted and Controlled Respiration. ARCHER S. GORDON, Los Angeles.
The Postoperative Chest X-ray. HIRAM T. LANGSTON, Chicago.
Diagnostic Techniques in Thoracic Disease. HERBERT C. MAIER, New York.
Question and Answer Period.

PLEUROPULMONARY DISEASE

PAUL C. SAMSON, Lafayette, California, Moderator.
Fungus Diseases of the Lung—Current Concepts of Treatment. JOHN W. POLK, Springfield, Missouri.
Surgery of the Trachea and Bronchus. DONALD L. PAULSON, Dallas.
Management of Nontuberculous Empyema and Its Complications. P. C. SAMSON, Lafayette, California.
Management of Pleural Tuberculosis. WILLIAM M. LEES, Chicago.
Pulmonary Suppuration. Ross ROBERTSON, Vancouver.
Question and Answer Period.

THE MEDIASTINUM AND DIAPHRAGM

JULIAN JOHNSON, Philadelphia, Moderator.
Tumors and Cysts. LAURENCE H. RUBENSTEIN, Chicago.
Surgery of the Thymus. O. THERON CLAGETT, Rochester, Minnesota.
Mediastinitis. JOHN Y. TEMPLETON III, Philadelphia.
Pericarditis. JULIAN JOHNSON, Philadelphia.
Lesions of the Diaphragm. DAVID J. DUGAN, Oakland.
Question and Answer Period.

THE ESOPHAGUS

RICHARD H. SWEET, Boston, Moderator.
Anatomy and Physiology. LUCIUS D. HILL, Seattle.
Endoscopic Techniques. PAUL H. HOLINGER, Chicago.
Lesions in Infancy and Childhood. CLIFFORD D. BENSON, Detroit.
Hiatus Hernia and Associated Esophagitis. K. ALVIN MERENDINO, Seattle.
Neoplasms. RICHARD H. SWEET, Boston.
Question and Answer Period.

Recent Advances in Pediatric Surgery

H. WILLIAM CLATWORTHY, JR., Columbus, *Chairman*
Tuesday through Friday, 8:30–11:30 a.m.

THE INFANT AND CHILD AS A SURGICAL PATIENT

H. WILLIAM CLATWORTHY, JR., Columbus, Moderator.
Psychic Trauma and Hospitalitis. H. WILLIAM CLATWORTHY, JR., Columbus.
Premedication and Anesthesia. ROBERT M. SMITH, Boston.
Fluids and Electrolytes. WILLIAM R. RICHARDSON, Oklahoma City.
Triage and Transportation. HARRY C. BISHOP, Philadelphia.
Pediatric Surgery. WILLIS J. POTTS, Chicago.

SURGERY OF THE INGUINAL AREA

WILLIAM H. SNYDER, JR., Los Angeles, Moderator.
Normal and Abnormal Testicular Descent. PETER K. KOTTMEIER, Columbus.
The Natural History of Hernias and Hydroceles. MICHEL GILBERT, Miami.
Torsion, Trauma, and Inflammation. WILLIAM L. RIKER, Chicago.
Tumors of the Testicle in Childhood. JOHN P. SMITH, Columbus.
Outpatient Surgery for Inguinal Anomalies. LORYE E. HACKWORTH, Los Angeles.

VASCULAR LESIONS

RICHARD L. VARCO, Minneapolis, Moderator.
Renal Hypertension. EUGENE F. POUTASSE, Cleveland.
Portal Hypertension. E. THOMAS BOLES, JR., Columbus.
Cardiovascular Surgery in Infants. WILLIAM T. MUSTARD, Toronto.
Hemangiomas and Their Management. LESTER W. MARTIN, Cincinnati.
Lymphangiomas and Cystic Hygromas. GEORGE W. HOLCOMB, JR., Nashville.

GENITOURINARY PROBLEMS

JOHN K. LATTIMER, New York, Moderator.
Intersex in Pediatric Gynecology. IRVING A. MEEKER, JR., Los Angeles.
Recurrent Pyuria. ALEXANDER J. MICHIE, Philadelphia.
Upper Urinary Tract Obstruction. ALBERT J. PAQUIN, JR., Charlottesville.
Ileal Loops for Urinary Incontinence. EUGENE M. BRICKER, St. Louis.
Acquired Megacolon and Fecal Incontinence. MARK M. RAVITCH, Baltimore.

FIG. 1.

FIG. 2.

FIG. 1. Patient 2. Acute suppurative cholangitis accompanying common duct obstruction secondary to calculus. The entire ductal system was distended with purulent material. The gallbladder was contracted over 3 gallstones.

FIG. 2. Decompression of the common duct was accomplished by T-tube drainage. Concomitant cholecystostomy with removal of calculi from gallbladder was carried out. Cholecystectomy was performed 3 months later and was followed by marked improvement.

Acute Obstructive Suppurative Cholangitis.—Frank Glenn and Frank G. Moody.